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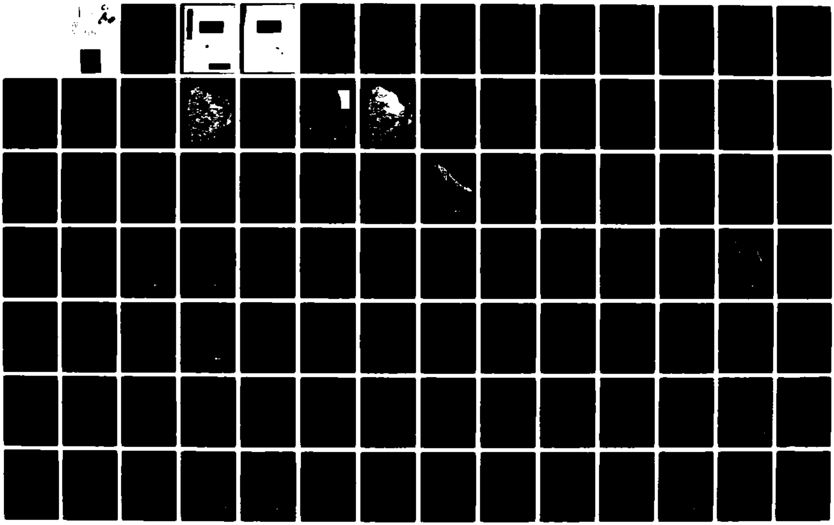

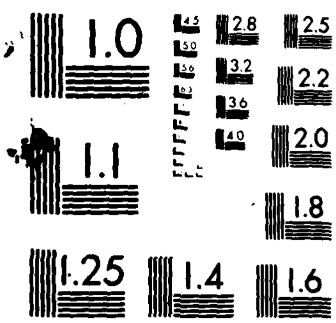

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: E-TR-47-MS	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Detailed Aggregate Resources Study Muleshoe Valley, Nevada	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER: E-TR-47-MS
7. AUTHOR(s): Ertec Western, Inc.	8. CONTRACT OR GRANT NUMBER(s): F04704-80-C-0006
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Ertec Western Inc (formerly Fugro National) [illegible]	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64312 F
11. CONTROLLING OFFICE NAME AND ADDRESS: [illegible] Air Force [illegible] Missile Systems [illegible]	12. REPORT DATE: 5 JUN 81
	13. NUMBER OF PAGES: 61
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Geology ~~Settings~~ ~~Road base~~ Aggregates, ~~Concrete Aggregates~~, grain size, petrography, caliche, soil, trench log

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Detailed aggregate resources study, Muleshoe Valley, Nevada. Report contains analysis, evaluation and quantity of aggregates resources found in the Muleshoe Valley. Classes RBIa, RBIb & RBII for Road-base. Classes CA1, CA2, CB, ~~an~~ CC1 and CC2 for concrete.

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E-TR-47-MS

MX SITING INVESTIGATION
GEOTECHNICAL EVALUATION

DETAILED AGGREGATE RESOURCES STUDY

MULESHOE VALLEY, NEVADA

Prepared for:

U.S. Department of the Air Force
Ballistic Missile Office
Norton Air Force Base, California 92409

Prepared by:

Ertec Western, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

5 June 1981

FOREWORD

This report is one of a series prepared for the Department of the Air Force, Ballistic Missile Office (BMO), in compliance with Contract No. F04704-80-C-0006, CDRL Item No. 004A2. These reports present the results of Detailed Aggregate Resources Studies within and adjacent to selected areas in Nevada and Utah that are under consideration for siting the MX missile system.

This volume contains the results of the aggregate resources evaluation for Muleshoe Valley. Results of this report are presented as text, appendices, and three drawings. This report has been prepared and submitted on the assumption that the reader is familiar with previous aggregate resources reports.

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EXECUTIVE SUMMARY

This report contains the Detailed Aggregate Resources Study (DARS) evaluation for Muleshoe Valley, Nevada. It is the third in a series of reports that contain detailed aggregate information on the location and quality of basin-fill and rock sources of road-base and concrete aggregates. Field reconnaissance, laboratory testing, and existing data from other Ertec Western, Inc. (formerly Fugro National, Inc.) investigations and the Nevada Department of Highways provide the basis for the findings presented in this report.

ROAD-BASE AGGREGATES

Potential road-base aggregate sources were classified as follows:

Class RBIa - Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.

Class RBIb - Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa source areas.

Class RBII - Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

Assignment of an aggregate source to one of the above three classes was determined from laboratory test results (gradation, abrasion and, to a lesser extent, soundness) and geomorphological and compositional correlations.

Results of this evaluation are presented on a 1:62,500 scale aggregate resources map (Drawing 2) and are summarized as follows:

<u>Class RBIa Sources</u>: Three basin-fill sources consisting of good- to high-quality aggregates acceptable for use as road-base construction materials have been located in Muleshoe Valley. These sources are all alluvial fans (Aaf).

Two crushed-rock sources which yielded good- to high-quality aggregates acceptable for use as road-base construction materials have been delineated within the study area. These sources are fairly extensive outcrops of undifferentiated carbonate rocks (Cau).

<u>Class RBIb Sources</u>: Four basin-fill deposits within the study area are defined as potential sources of good- to high-quality, road-base aggregates. Geomorphological and compositional similarities were used to correlate these units to tested RBIa deposits. These deposits are all alluvial fans.

<u>Class RBII Sources</u>: Four potential basin-fill aggregate sources are located within the study area. All of these sources are alluvial fans that have been classified on the basis of limited field and laboratory data.

CONCRETE AGGREGATES

A classification system consisting of five classes was developed for the concrete aggregates evaluation to present potential basin-fill and crushed-rock sources. Although most rock sources will supply coarse concrete aggregates, their delineation was not an objective of this study. Assignment of an aggregate source to one of the five classes was determined from laboratory test results (trial concrete mixes and gradation, abrasion, and soundness of aggregates) and geomorphological and compositional

correlations. The emphasis of this study was the evaluation of the concrete-making properties (especially 28-day compressive strengths) of potential aggregates when used in trial concrete mixes.

Class CA1	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths equal to or greater than 6500 psi.
Class CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi.
Class CB	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on acceptable laboratory aggregate test results.
Class CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 and CA2 source areas.
Class CC2	Basin-fill sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CB source areas.

The following three trial mixes were used to obtain a range of compressive strength values; however, only Mix 3 results were used to classify sources. In all three trial mixes, fly ash, as a pozzolan, replaced 20 percent of the cement by weight.

- o Mix 1 - 7.5 sacks of cement per cubic yard of concrete and 1.5-inches maximum aggregate size;
- o Mix 2 - 8.5 sacks of cement per cubic yard of concrete and 1.5-inches maximum aggregate size; and
- o Mix 3 - 8.5 sacks of cement per cubic yard of concrete, 0.75-inch maximum aggregate size, and a superplasticizer.

Results of this evaluation are presented on a 1:62,500 scale aggregate resources map (Drawing 3) and summarized as follows:

<u>Class CA1 Sources</u>: There is one crushed-rock aggregate source in the study area that produced a 28-day compressive strength in excess of 6500 psi. This source consists of undifferentiated carbonate rock (Cau). A nearby fine aggregate source used in conjunction with the crushed rock in the concrete trial mixes had a high magnesium sulfate soundness loss.

Sufficient quantities of poor- to fair-quality fine aggregates are available in most basin-fill deposits. High-quality, fine aggregate sources are lacking or of limited extent within the study area.

<u>Class CB Sources</u>: Three basin-fill deposits consisting of good- to high-quality aggregates, potentially acceptable for use as concrete construction materials, were delineated in the valley. All of these deposits are alluvial fans. Fine aggregates within the deposits are of poor to fair quality based on limited data.

<u>Class CC1 Sources</u>: There are several Class CC1 rock aggregate sources within the study area correlated to the Class CA1 crushed-rock aggregate sources. These correlations are based on lithologic similarities.

<u>Class CC2 Sources</u>: Four alluvial fan units in the valley are potential sources of aggregates suitable for use in concrete. They are correlated to Class CB units on the basis of geomorphological and compositional similarities.

CONCLUSIONS

Sufficient quantities of coarse and fine aggregates suitable for use as road-base and/or concrete construction material are available in Muleshoe Valley. Laboratory test results indicate that the quality of the coarse aggregates ranges from good to excellent and the quality of the fine aggregates ranges from poor to fair.

RECOMMENDATIONS

Additional aggregate field investigations and laboratory testing will be required to further refine the physical and chemical characteristics of road-base and concrete aggregate sources as borrow areas prior to the initiation of construction.

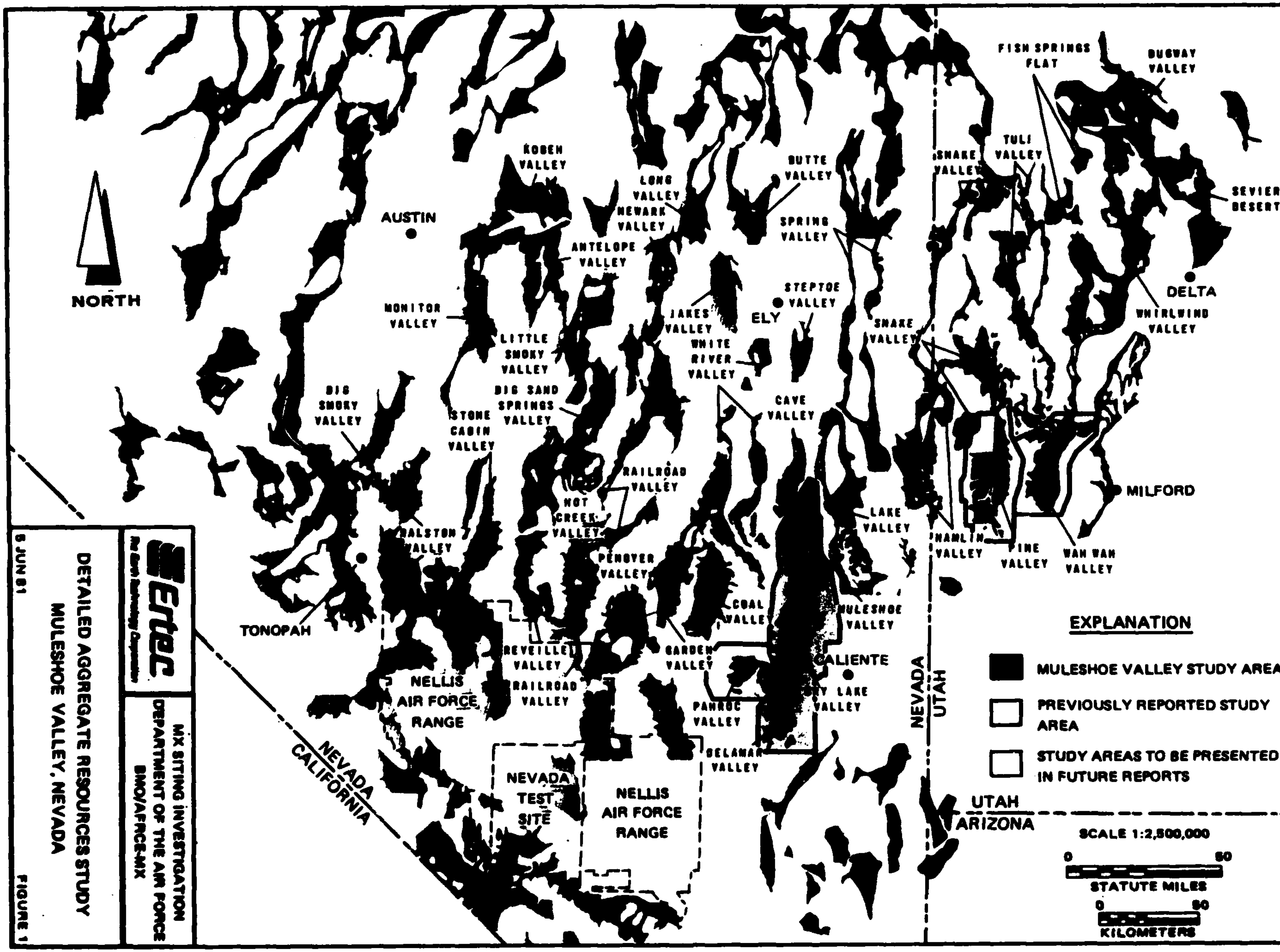
1.0 INTRODUCTION

1.1 STUDY AREA

This report presents the results of the Detailed Aggregate Resources Study (DARS) for Muleshoe Valley (Figure 1). Muleshoe Valley is the northern extension of Dry Lake Valley and is located in northern Lincoln County, Nevada. It is bounded on the west and north by the Schell Creek Range, and on the east by Dutch John and Grassy mountains and the Fairview Range. The southern limit of Muleshoe Valley is the township line which divides Township 4 North from Township 3 North (Mt. Diablo baseline and meridian). U.S. Highway 93 is the only paved road in the vicinity, but a network of graded roads and four-wheel-drive trails provide access to most parts of the study area. The valley is mainly undeveloped desert rangeland administered by the Bureau of Land Management (BLM). The nearest town is Pioche, Nevada, located approximately 40 miles (64.4 km) southeast of the valley on U.S. Highway 93.

1.2 BACKGROUND

Aggregate resources studies for the MX program were introduced in 1977 with the investigation of Department of Defense (DoD) and BLM lands in California, Nevada, Arizona, New Mexico, and Texas (FN-TR-20D). Refinement of the MX siting area added portions of Utah and Nevada that were not evaluated in this initial Aggregate Resources Evaluation Investigation (AREI). This additional area, defined as the Utah-Nevada aggregate resources study area, was examined in the fall of 1979, and a



DETAILED AGGREGATE RESOURCES STUDY
MULESHOE VALLEY, NEVADA

5 JUN 81

FIGURE 1

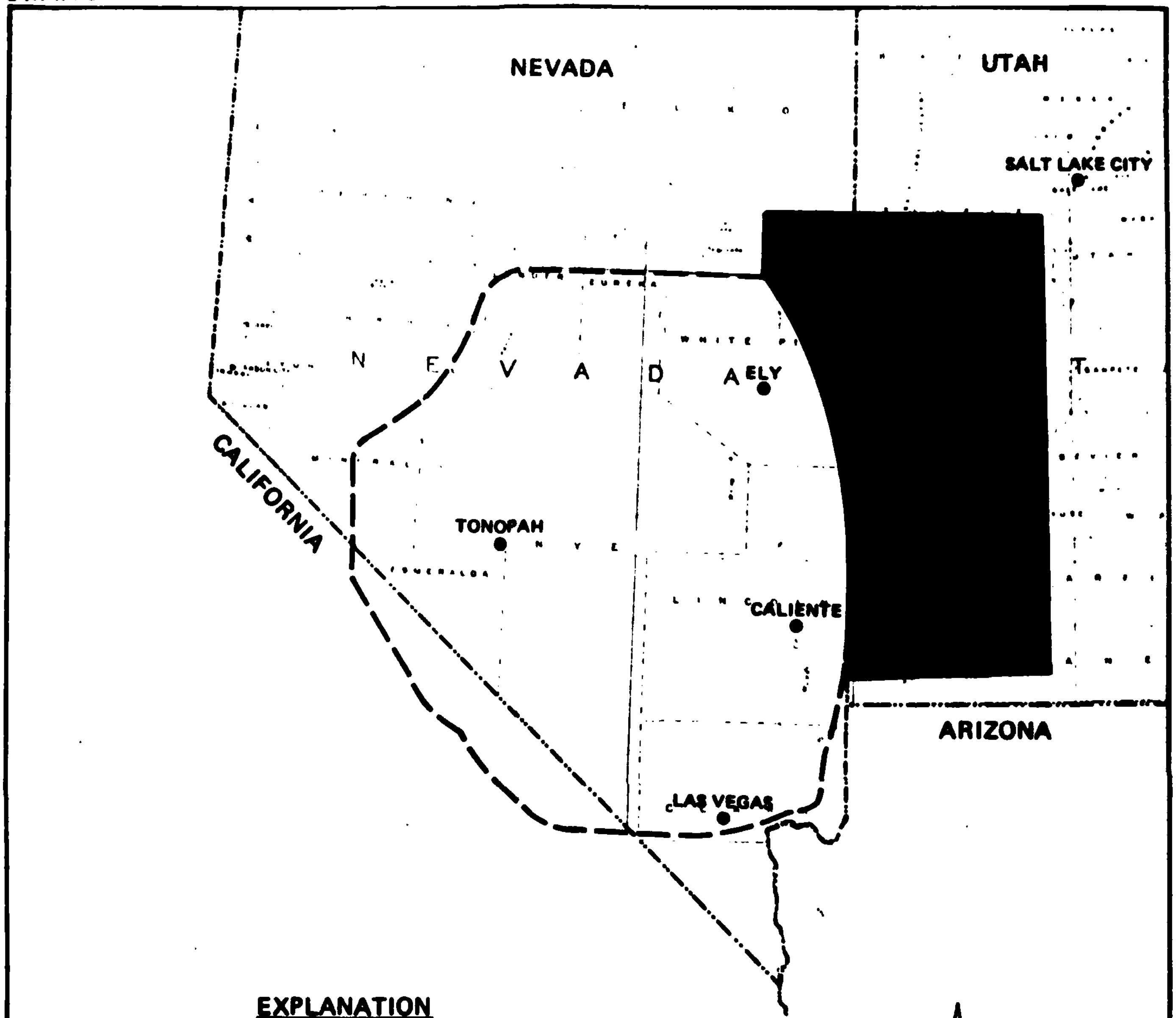
second regional aggregate resources report was submitted on 3 March 1980 (Figure 2).

Both regional aggregate investigations consisted of the compilation and evaluation of existing data with limited field reconnaissance, sample collection, and laboratory aggregate testing. Only general information on the location, quality, and quantity of aggregates was provided.

Subsequent to the regional studies, Valley-Specific Aggregate Resources Studies (VSARS) were started in FY 79. The primary objective of these continuing studies is to provide additional information on potential aggregate sources in specified valleys and in the areas immediately surrounding them. Existing exposures of potential basin-fill and rock aggregate sources are sampled and subjected to a suite of laboratory tests. Results of these tests are used to classify coarse and fine basin-fill and crushed-rock aggregates for suitability as concrete and road-base construction materials.

The aggregate sources presented in the VSARS are to be used as a guide for preliminary construction planning and the selection of areas for more detailed-aggregate evaluations. To date, field investigations have been completed for 16 valley areas with final reports submitted for 11 valley areas (Figure 3). Field investigations for remaining valleys in the designated deployment area are planned in FY 81 and FY 82.

The DARS were initiated in FY 81 to further analyze and refine potential sources of coarse and fine basin-fill and crushed-rock



EXPLANATION

NEVADA–CALIFORNIA AGGREGATE RESOURCES STUDY AREA, FY 78 (FN-TR-20D)

UTAH AGGREGATE RESOURCES STUDY AREA, FY 79

NORTH

SCALE 1: 5,000,000

0 50 100
STATUTE MILES

0 50 100
KILOMETERS

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DEPARTMENT OF THE AIR FORCE
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UTAH–NEVADA REGIONAL AGGREGATE STUDIES

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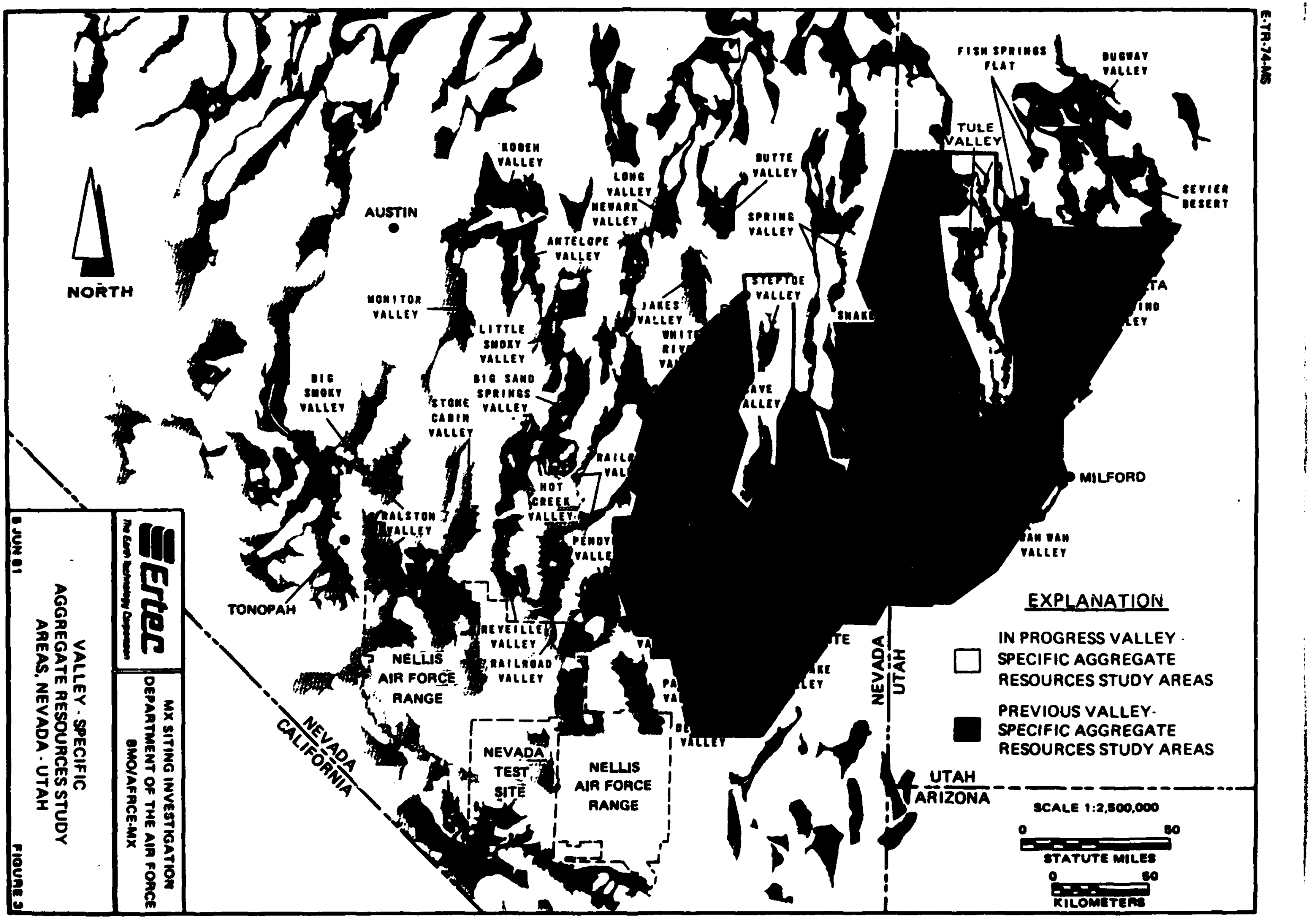
FIGURE 2



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VALLEY - SPECIFIC
AGGREGATE RESOURCES STUDY
AREAS, NEVADA - UTAH

8 JUN 81

FIGURE 3

aggregates identified during the VSARS. These studies consist of both road-base (Section 3.0) and concrete (Section 4.0) aggregate evaluations. The major consideration was to further evaluate basin-fill deposits as potential sources of road-base and concrete aggregates. Limited new data were developed on crushed-rock sources.

1.3 OBJECTIVES

The objectives of the Detailed Aggregate Resources Study are as follows:

Road-Base Aggregates Evaluation

- Refine potential basin-fill and rock sources (initially identified in VSARS) for road-base aggregates; and
- Provide additional laboratory test data on the general quality of basin-fill aggregates for use as road-base material.

Concrete Aggregates Evaluation

- Refine the areal extent of the most acceptable VSARS basin-fill and rock, concrete aggregate sources; and
- Provide additional laboratory testing information on the quality and the concrete-making properties of potential coarse and fine basin-fill and crushed-rock aggregates.

1.4 SCOPE

The scope of the two evaluations required office and field studies and included the following:

a. Compilation and analysis of appropriate existing data on the quality and quantity of potential road-base and concrete aggregates. Major sources of data were other Ertec investigations for the siting of the MX system and the Nevada Department of Highways.

b. Initial and final basin-fill deposit differentiation based on geomorphology, grain-size, lithology, and aerial photography and topographic map interpretation. Initial and final

rock unit divisions based on evaluations of aerial photography and published geologic maps.

c. Staking and permitting on selected BLM lands. Appropriate basin-fill trench locations for samples of road-base and concrete aggregates were determined from items a and b and a brief field reconnaissance.

d. Backhoe excavation of staked and permitted basin-fill locations, sampling when gravel percentage exceeded 30 percent, or when suitable fine aggregates for concrete mixes were present. Selection and sampling of acceptable crushed-rock sources of coarse aggregates for concrete mixes.

e. Valley-wide field reconnaissance utilizing aerial photography and petrographic and grain-size analyses to determine lateral extent and acceptability of basin-fill deposits.

f. Laboratory tests to supplement available existing data for the determination of the suitability of specific basin-fill and rock units as sources of road-base or concrete aggregates. Trial (check) concrete mixes were made to evaluate the basic concrete-making properties of selected concrete aggregate sources as well as engineering properties of hardened concrete.

g. Development and application of road-base and concrete materials classification systems that textually and graphically depict the locations of the most suitable aggregate sources in the study area. The depiction and discussion of areas that are unsuitable or have a low probability for use were not done.

2.0 GEOLOGIC SETTING

2.1 PHYSIOGRAPHY

Muleshoe Valley lies within the Basin and Range Physiographic Province and exhibits characteristic north-south trending, block faulted, mountain ranges with an intervening alluvial basin. Elevations within the valley range from 6462 feet (1970 m) at the northern end to approximately 5200 feet (1585 m) in the south-central part of the valley.

Mountain ranges flanking the basin are the Schell Creek Range on the west and northwest and the Fairview Range and Dutch John and Grassy mountains on the east. Muleshoe Valley is topographically open to Dry Lake Valley to the south. Topographic relief between mountain ridges and the basin is greatest along the eastern margin of the valley and varies from about 3000 feet (914 m) to 3650 feet (1112 m). Muleshoe Valley has an open drainage system, draining south into Dry Lake Valley.

2.2 LOCATION AND DESCRIPTION OF GEOLOGIC UNITS

Paleozoic, Mesozoic, and Cenozoic rocks are exposed in outliers and in the mountains surrounding Muleshoe Valley. Paleozoic rocks consist predominantly of limestone and dolomite, with lesser amounts of interbedded shale and quartzite or indurated sandstone. These sediments crop out across the entire study area and, where not exposed, underlie younger geologic units. Mesozoic deposits consist of older undifferentiated volcanic rocks. Cenozoic rocks unconformably overlie all older rocks

and consist of Tertiary volcanic rocks and late Pliocene to Quaternary alluvial fans and stream-channel and terrace deposits.

Specific Paleozoic, Mesozoic, and Cenozoic geologic units have been grouped into one rock and one basin-fill category for use in discussing potential aggregate sources. The grouping of the units was based on similarities in physical and chemical characteristics and map-scale limitations. The resulting categories simplify discussion and presentation without altering the conclusions of the study.

Additional geologic information is presented in previous and in progress Ertec Western reports (FN-TR-37-a; and E-TR-27-MS-I and II).

2.2.1 Rock Units

There is one major potential source of crushed-rock aggregate in Muleshoe Valley, carbonate rocks undifferentiated (Cau). While all other rock units may locally supply aggregates, insufficient test data prohibit their consideration as major aggregate sources, and they will not be discussed in this report.

Materials classified as undifferentiated carbonate rocks include thick, complex sequences of limestone and dolomite with thin interbeds of quartzite, shale, and sandstone. Principal formations in this unit are the Middle Devonian Guilmette Formation and a Permian and Pennsylvanian undivided limestone and calcareous sandstone. The Guilmette Formation is exposed on the western side of the valley in the Schell Creek Range. The undivided limestone is widely distributed in Grassy Mountain on

the northeast side of the valley and in the Schell Creek Range on the west side of the valley. All of the undifferentiated carbonate rocks are typically light- to dark-gray in color, thin- to very thick-bedded, hard, locally cherty, fossiliferous, and resistant cliff-formers.

2.2.2 Basin-Fill Units

The basin-fill geologic units within the study area that are potential sources of coarse and fine aggregates are alluvial fan deposits (Aaf). All other basin-fill units may locally supply aggregates but are not considered major sources and will not be discussed in this report.

2.2.2.1 Alluvial Fan Deposits - Aaf

Alluvial fans that are potential sources of basin-fill aggregates occur along the southwest and northwest sides of the valley. Alluvial fan units are typically heterogeneous to poorly stratified mixtures of boulders, cobbles, gravel, sand, silt, and clay. The predominant material within these deposits is sandy gravel. Most alluvial fan units have developed soil horizons consisting of silty, clayey sand a few inches (centimeters) to 1 foot (0.3 m) in thickness, overlying a zone of carbonate accumulation (caliche). Caliche horizons generally range in thickness from 1 to 5 feet (0.3 to 1.5 m) and exhibit Stage II to III development (Appendix Table F-2).

3.0 ROAD-BASE AGGREGATES EVALUATION

3.1 STUDY APPROACH

The primary objective of the road-base aggregate study was to evaluate the suitability of basin-fill and rock aggregates for use as road base. Two important considerations were applied to basin-fill aggregate sources identified as potentially suitable in VSARS, refinement of source boundaries, and additional laboratory tests to further evaluate physical and chemical characteristics. Sources of crushed-rock aggregates were refined using only existing data, published geologic maps, and limited photogeologic interpretations. Information on potential rock sources for use as road-base aggregates was not specifically collected for this evaluation. Only existing VSARS data and data developed from the concrete aggregates evaluation (Section 4.0) were assessed.

The study approach for the road-base aggregates evaluation required a review of in-progress Ertec Verification (E-TR-27-MS-I and II) and previous Ertec aggregate reports (FN-TR-20D and FN-TR-37-a) for Muleshoe Valley. This data base helped define the scope of the road-base materials investigation which included office and field photogeologic and topographic interpretations, field reconnaissance, and collection and laboratory testing of basin-fill samples.

3.1.1 Requirements for Road-Base Aggregates

For the purpose of this report, road-base aggregates are defined using the Nevada Department of Highways (1976) classification of

Type I Class A aggregate base. The requirements for aggregates suitable for such a base are as follows:

Gradation:

Sieve Size	Percent Passing by Weight
1.5 inches	100
1.0 inch	80-100
No. 4	30- 65
No. 16	15- 40
No. 200	2- 12

Fractured Faces .... 35 percent, minimum
Plasticity Index .... 3-15 percent
Liquid Limit .... 35 maximum
Resistance (R value) .... 70 minimum
Percent Wear (500 Rev.) .... 45 percent, maximum

During the road-base aggregate studies, gradation and percent wear were the two primary criteria used to evaluate potential source areas. Magnesium sulfate ($MgSO_4$) soundness tests were performed on selected coarse aggregate samples to gain additional information related to the effects of weathering on aggregates. Soundness losses exceeding 18 percent were considered potentially unacceptable (American Society of Testing and Materials, 1978). The remaining requirements were not evaluated during this study.

3.1.2 Data Acquisition and Analysis

Office studies for the road-base aggregates evaluation required preliminary basin-fill and rock unit differentiation based on photogeologic interpretations and published topographic and geologic maps. All available data on basin-fill, grain-size gradations were compiled to estimate gravel content for the defined basin-fill units.

The field program involved backhoe excavation of 10 trenches selected during office studies and initial field reconnaissance. Trenches were generally excavated and sampled in groups of two or three, 0.1 to 0.2 mile (0.2 to 0.3 km) apart, to characterize individual basin-fill units. Completion depths ranged from 12 to 15 feet (3.7 to 4.6 m) and, where collected, representative samples averaged 100 pounds (45 kg) per trench.

Due to gradation variability in basin-fill deposits, field limits of 30 percent or more gravel and 20 percent or less silt and clay were established as basic aggregate grain-size distribution requirements. Gravel is defined as coarse aggregates which pass the 3.0-inch (75-mm) sieve and are predominantly retained on a No. 4 (4.75-mm) sieve. Aggregates larger than 3.0 inches (cobbles and boulders) were generally present in the materials investigated but were not included in the laboratory samples because of sample-size limitations. Silt and clay particles are defined as material passing through a No. 200 sieve (0.0029-inch [0.075-mm]).

Field studies also included 16 petrographic and grain-size data field stops and valley-wide photogeologic field reconnaissance. These analyses were performed to supplement and confirm office studies and to provide a data base for lithologic and gradation correlations of basin-fill units.

Laboratory testing that included nine sieve analyses, four abrasion tests, and two $MgSO_4$ soundness tests was performed to

broaden the existing data base during the road-base aggregates evaluation.

The scope of the study did not allow sample collection and laboratory testing of all potential road-base aggregate sources. Existing data and field petrographic and grain-size analyses were used to correlate lithologic and gradation properties to basin-fill units which were not sampled. An important element of this correlation procedure was the use of aerial photography to help delineate the lateral extent of basin-fill deposits. Photogeologic and field observations ascertained geomorphological and topographical relationships of basin-fill units and the source rock lithology and distribution of predominantly gravelly materials.

3.1.3 Presentation of Results

Results of the road-base aggregates evaluation are presented in the form of text, figures, 1:62,500 scale drawings, and appendices. Drawing 1 shows the locations of all the data points used in the Detailed Aggregate Resources Study. The data points are grouped by study type and assigned categorized map numbers. VSARS data points are designated by map numbers 1 to 199 and correspond to map numbers in the appendix table of the Muleshoe area VSARS report (FN-TR-37-a). DARS data points are assigned map number groups 200 to 299 for trench locations and 300 to 399 for petrographic and grain-size data stop locations. Verification data points are assigned the map number group 400 to 599. Appendix Table G-1 converts map number to the in-progress

Muleshoe Verification Report (E-TR-27-MS-I and II) activity type and number for direct reference.

Drawing 2 presents the locations of all potential road-base aggregate sources, DARS trenches, select VSARS data stops, and field petrographic and grain-size data stops in the study area. Geologic unit symbols used in Drawing 2 relate to standard geologic nomenclature whenever possible. A conversion table relating these symbols to the geologic unit nomenclature used in other Ertec reports is contained in Appendix Table F-3.

A solid contact line separates basin-fill and rock units in Drawing 2 to differentiate these two basic material types. All rock contacts are from published data or limited air-photo interpretation and are dashed. Basin-fill contacts are derived from photogeological mapping with limited field reconnaissance and are also dashed.

Classifications of potential sources of basin-fill and crushed-rock road-base aggregates are distinguished by different patterns. Patterns for basin-fill and rock sources of the same classification are similar, with the basin-fill pattern emphasized by a dark background tone.

The appendices contain tables that summarize the basic field data collected during the course of the study and the subsequent laboratory test procedures and results. Appendices A and B include DARS trench data and petrographic and grain-size analysis data, respectively. Appendix C contains representative trench

logs. Appendix Table D-1 presents a laboratory testing flow diagram for the road-base aggregates evaluation. Appendix F includes three tables describing soil classification, caliche development, and geologic unit cross reference.

3.1.4 Classification of Road-Base Aggregates

A classification system was designed to present the most likely locations of potential sources of basin-fill and crushed-rock road-base aggregates. It was developed from an evaluation as well as from an extrapolation of all available data.

This classification system is primarily based on laboratory test results (gradation and abrasion and, to a lesser extent, soundness) and geomorphological and compositional correlations. The classification is presented in hierarchy form; classification of the highest potential source areas is described first and classification of the lowest potential source areas is described last.

Class	Explanation
RBIa	Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.

Class RBIa includes those source areas where the potential for suitable road-base aggregates is the highest. Each delineated area has been sampled and tested. In order to assign Class RBIa to a basin-fill deposit, the source must satisfy the overall requirements outlined in Section 3.1.1.

Class	Explanation
RBIb	Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa source areas.

Class RBIb basin-fill sources are correlated to tested RBIa deposits on the basis of limited laboratory sieve analysis data and field observations. Field observations included petrographic and grain-size analyses which provided data on lithology of adjacent source rock and general amounts and lithologies of gravel present in the basin-fill units. Photogeologic interpretations were also used to correlate Class RBIb deposits to RBIa deposits. Specific geomorphological parameters included surface texture, drainage patterns, relative relief, and topographic profiles.

Class	Explanation
RBII	Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

Class RBII includes poorly defined, basin-fill aggregate sources. Field observations and inconclusive field and laboratory data indicate these deposits may be potentially acceptable for use as road-base aggregate sources.

All classifications are based on limited data. Additional field reconnaissance, testing, and case history studies are needed to

confirm adequacy, delimit exact areal boundaries, and refine chemical and physical characteristics.

3.2 SOURCES OF ROAD-BASE AGGREGATES

The potential basin-fill and rock units defined for use as road-base aggregates in the Muleshoe Valley study area include alluvial fan deposits (Aaf) and undifferentiated carbonate rocks (Cau).

3.2.1 Basin-Fill Sources

All three classes of road-base aggregates, RBIa, RBIb, and RBII, are present in the basin-fill units of Muleshoe Valley (Drawing 2).

3.2.1.1 Class RBIa

Class RBIa deposits within the study area are located adjacent to Dutch John and Grassy mountains and along the southwestern margin of the valley, adjacent to the Schell Creek Range.

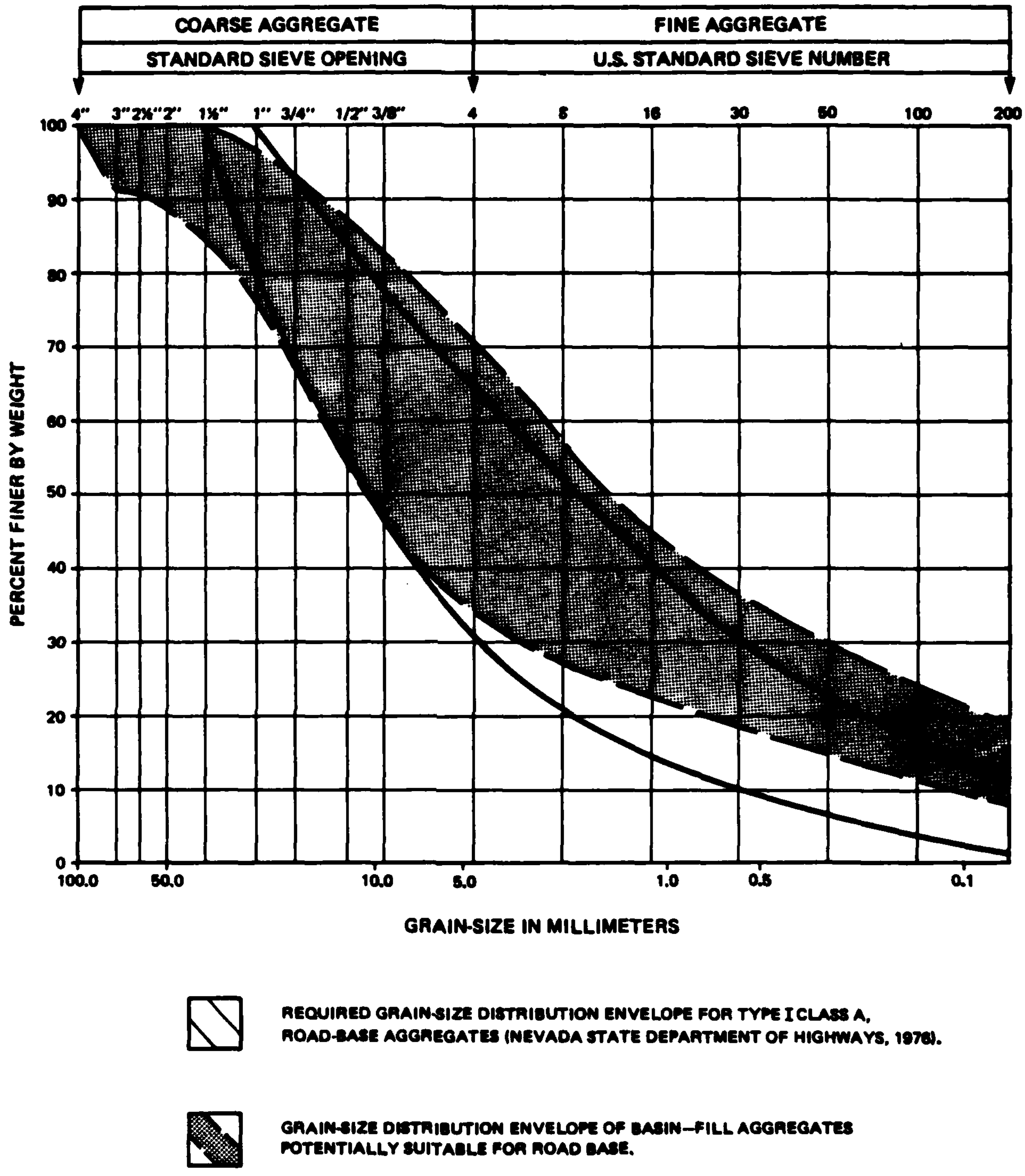
There are three Class RBIa basin-fill deposits in the study area. They generally consist of poorly to well-graded, subrounded sandy gravel and gravelly sand. The gravel content of these deposits ranges from 28 to 56 percent, the sand content ranges from 19 to 37 percent, and the silt and clay content ranges from nine to 20 percent. The Class RBIa deposits located in the southwest and northeast parts of the valley are composed predominantly of carbonate clasts with some quartzite and minor volcanic clasts. The east-central Class RBIa deposit differs from the other two by containing predominantly volcanic clasts with a lesser amount of carbonate clasts.

The gradation of Class RBIa sources approximates the grain-size distribution requirements stated in Section 3.1.1 (Figure 4). The different RBIa deposits generally show the same gradation characteristics; cobbles and coarse gravel (oversize material) are present, gravel passing the 1.5- to 1-inch sieves are deficient in some cases, and fine gravel and sand passing the 1-inch to No. 200 sieves are within design gradation requirement. There is one exception to the gradation trend of RBIa sources. The east-central RBIa deposit is excessive in the amount of sand passing the No. 4 to No. 200 sieves. Minor processing of all RBIa deposits will be necessary to conform to the gradation requirements.

It has been observed that variations in grain-size gradations occur within a deposit depending on sample location. In general, gradations within a deposit are finer near the valley axis and coarser near the mountain fronts. Due to access restrictions, samples were generally collected at distal and medial locations within each deposit.

Laboratory abrasion tests performed on samples from all Class RBIa deposits show a fairly narrow range of 25.5 to 34.5 percent wear. A $MgSO_4$ soundness test performed on a sample of aggregate from a Class RBIa deposit yielded a low value of 6.6 percent loss for the coarse aggregates but a high value of 26.5 percent loss for the fine aggregates.

Individual Class RBIa deposits range in areal extent from 2.1 to 4.4 mi^2 (5.4 to 11.4 km^2). The thickness of these deposits



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GRAIN-SIZE DISTRIBUTION ENVELOPES
ROAD-BASE AGGREGATES, CLASS RBIa
MULESHOE VALLEY, NEVADA

5 JUN 81 FIGURE 4

is estimated to be at least 25 feet (7.6 m). Generally, 70 to 90 percent of the material in these deposits will be suitable for use as road-base aggregates.

3.2.1.2 Class RBIb

Class RBIb basin-fill aggregate sources consist of alluvial fan deposits that have been correlated to Class RBIa deposits and, therefore, are considered to contain material acceptable for use as road-base aggregates. Class RBIb basin-fill deposits occur along the east side of the valley, adjacent to Grassy Mountain, and along the southwestern side of the valley, adjacent to the Schell Creek Range. Four alluvial fan units (Aaf) are included in this classification.

Since Class RBIb basin-fill deposits are correlated to Class RBIa deposits, they possess the same general characteristics poorly to well-graded, subrounded sandy gravel and gravelly sand consisting predominantly of carbonate clasts.

Although variations in grain-size gradations will occur, depending on sample location within the deposit and the proximity of the deposit to its source area, Class RBIb deposits are interpreted to have gradation distributions similar to RBIa deposits.

The Class RBIb aggregate deposits range in surface area from approximately 1.4 to 7.8 mi^2 (3.6 to 20.2 km^2). The thickness of these deposits has been estimated to be at least 25 feet (7.6 m). Generally, from 70 to 90 percent of the material in the Class RBIb deposits will be suitable for use as road-base aggregates.

3.2.1.3 Class RBII

Class RBII basin-fill aggregate sources are four alluvial fan deposits that are potentially acceptable for use as road base. These deposits have been classified on the basis of limited field and laboratory data collected during this and other Ertec studies.

Class RBII sources are located on the east side of the valley, adjacent to Grassy Mountain, and on the southwest side of the valley, adjacent to the Schell Creek Range.

Limited laboratory and field data used to define the Class RBII deposits in the valley indicate that they are compositionally similar to RBIa and RBIb deposits, composed of sandy gravel and gravelly sand consisting predominantly of carbonate clasts with secondary volcanic and quartzite clasts. However, there may be considerable variations from this general description within individual deposits.

The areal extent of the Class RBII deposits range from approximately 3.2 to 7.3 mi^2 (8.3 to 18.9 km^2).

3.2.2 Rock Sources

The study approach used to evaluate road-base aggregates emphasized the analysis of basin-fill deposits and dictated that only previously tested, crushed-rock sources be discussed and classified. As a consequence, other rock units potentially suitable as sources of crushed-rock, road-base aggregates are not included or described in this study.

Sources of crushed rock for use as road-base aggregates are undifferentiated carbonate rocks (Cau) classified as RBIa. These sources are located at two widely spaced locations within the Muleshoe Valley study area, on the east side of the valley at Grassy Mountain and on the west side of the valley in the Schell Creek Range.

Results of laboratory abrasion tests performed on samples from the Class RBIa carbonate rocks range from 33.3 percent to 35.2 percent wear. Laboratory $MgSo_4$ soundness test results range from 2.2 to 5.6 percent loss. These test results are well within the acceptable ranges for road-base aggregates.

4.0 CONCRETE AGGREGATES EVALUATION

4.1 STUDY APPROACH

The purpose of the concrete aggregates evaluation is to determine the suitability of aggregates within Muleshoe Valley for use in concrete. To accomplish this, two objectives have been established:

- o Evaluate the basic physical and chemical characteristics of the aggregates; and
- o Determine the concrete-making properties of the aggregates.

The study approach required to achieve these objectives included a review of in-progress Ertec Verification (E-TR-27-MS-I and II) and previous Ertec aggregate reports (FN-TR-20D and FN-TR-37-a). This data base helped define the scope of the concrete aggregates investigation and included office and field photogeologic and topographic interpretations, field reconnaissance, and collection and laboratory testing of basin-fill and rock samples.

4.1.1 Requirements for Concrete Aggregates

The following requirements for aggregates and concrete (made using these aggregates) were established using criteria from the American Society of Testing and Materials (1979), the "Concrete Manual" prepared by the United States Department of the Interior (1975), and from Milos Polivka (1981, personal communication).

1. Aggregates

   - o Gradation - The aggregate gradation specifications used by the American Society of Testing and Materials (1979, C 33) were selected for evaluating the samples tested. These grading specifications follow.

Coarse Aggregates

Sieve Size	Percent Passing by Weight	Sieve Size	Percent Passing by Weight
2 inches	100	1 inch	100
1.5 inches	95-100	0.75 inch	90-100
1 inch	---	0.5 inch	---
0.75 inch	35-70	0.375 inch	20-55
0.50 inch	---	No.4	0-10
0.375 inch	10-30	No.8	0-5
No.4	0-5		

Fine Aggregates

Sieve Size	Percent Passing by Weight
0.375 inch	100
No.4	95-100
No.8	80-100
No.16	50-85
No.30	25-60
No.50	10-30
No.100	2-10
No.200	

- o Abrasion - Los Angeles Machine abrasion losses for coarse aggregates are not to exceed 50 percent.

- o Soundness - Five-cycle magnesium sulfate ($MgSO_4$) soundness losses are not to exceed 18 percent and 15 percent for coarse and fine aggregates, respectively. Although not a requirement for the evaluation, five-cycle sodium sulfate ($NaSO_4$) soundness tests are performed on samples that failed $MgSO_4$ testing. Resultant losses are not to exceed 12 percent and 10 percent for coarse and fine aggregates, respectively.

- o Reactivity - Aggregates are to be nonreactive to alkali-silica and alkali-carbonate rock tests. Results are incomplete and will be submitted as an addendum to this report.

2. Concrete

- o Compressive Strength - The primary concrete requirement is a 28-day compressive strength equal to or greater than 6500 psi.

- o Static Modulus of Elasticity - Values of 3 to 6 million psi at 28 days required.
- o Splitting Tensile Strength - Ten percent or less of the compressive strength value at 28 days required.
- o Ultimate Drying Shrinkage - Values of 0.03 to 0.10 percent (300 to 1000 millionths) required.

4.1.2 Data Acquisition and Analysis

4.1.2.1 Office Studies

Office studies for the concrete aggregates evaluation required preliminary basin-fill and rock unit differentation based upon photogeologic interpretations and published topographic and geologic maps. All available data on basin-fill, grain-size gradations were compiled to estimate gravel content for the defined basin-fill units. All available test data on the aggregate properties of basin-fill and rock units were compiled to select sample locations in units previously tested and found preliminarily acceptable for use as concrete aggregate sources.

4.1.2.2 Field Studies

The field program involved backhoe excavation of six trenches selected during office studies, fine aggregate and crushed-rock sample collection, and initial field reconnaissance. Five trenches were excavated to obtain samples of coarse and fine aggregates for a potential trial concrete mix. Well-developed caliche caused backhoe refusal at shallow depths and samples were not collected. A sixth trench was excavated to investigate a fine aggregate source and collect a sample weighing approximately 800 pounds (364 kg). A bulk sample of surface rock,

manually collected to accompany the fine aggregate sample, weighed about 1200 pounds (545 kg).

Field studies also included 14 petrographic and grain-size data field stops and valley-wide photogeologic field reconnaissance. These analyses were performed to supplement and confirm the office studies and to provide a broader data base for lithologic and gradation correlations of basin-fill units.

4.1.2.3 Laboratory Testing

The laboratory aggregate testing program was performed in two phases. The first phase consisted of standard tests for determining the basic properties of the aggregates and included the following:

- o Unit Weights and Voids in Aggregates;
- o Standard Specifications for Concrete Aggregates;
- o Soundness of Aggregates, Magnesium Sulfate ($MgSO_4$) and Sodium Sulfate ($NaSO_4$);
- o Sieve Analysis by Washing, less than No. 200 fraction;
- o Fineness Modulus;
- o Specific Gravity and Absorption, Coarse and Fine Aggregates;
- o Resistance to Abrasion, Los Angeles Machine;
- o Sieve Analysis, Coarse and Fine Aggregates; and
- o Petrographic Examination of Aggregates for Concrete.

Generally, these tests were performed on aggregates from different locations within the same sources previously tested and identified as the most promising in the VSARS program. This repetitive testing was done to confirm the suitability of

aggregates for concrete (see Section 4.1.1, Requirements for Concrete Aggregates). Table 1 lists the number of tests completed in Muleshoe Valley.

The second phase of the testing consisted of an evaluation of the concrete-making properties of the aggregates when used in the following three trial (check) concrete mixes.

Mix 1 - 7.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 1.5-inches maximum aggregate size.

Mix 2 - 8.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 1.5-inches maximum aggregate size.

Mix 3 - 8.5 sacks (94 pounds per sack) of cement per cubic yard of concrete with 0.75-inch maximum aggregate size and a superplasticizer.

In all three trial mixes, fly ash, as a pozzolan, replaced 20 percent of the cement by weight. All concrete trial mix design criteria are presented in Table 2. Samples were collected for one trial mix set, consisting of crushed rock (coarse aggregates) and basin fill (fine aggregates). Material greater than 1.5 inches was crushed to conform to gradation requirements. If necessary, coarse and fine aggregates were processed to conform to gradation requirements.

The following tests were performed to evaluate fresh and hardened properties of concrete made from Muleshoe Valley aggregates:

<u>Fresh Properties</u>

- o Unit Weight, Yield and Air Content of Concrete;
- o Slump of Portland Cement Concrete;

	ASTM STANDARD TEST	AGGREGATE AND CONCRETE TEST DESCRIPTIONS[1]	TOTAL NUMBER OF TESTS*			
			BASIN-FILL		ROCK	
			CA	FA	ROCK	FA
AGGREGATES	C29	UNIT WEIGHT AND VOIDS IN AGGREGATE	–		1	
AGGREGATES	C33	STANDARD SPECIFICATIONS FOR CONCRETE AGGREGATE	–		1	
AGGREGATES	C88	SOUNDNESS OF AGGREGATE: $MgSO_4/NaSO_4$	–	–	1/–	1/1
AGGREGATES	C117	SIEVE ANALYSIS BY WASHING, < # 200 FRACTION	–		–	1
AGGREGATES	C125	FINENESS MODULUS	–	–	–	1
AGGREGATES	C127	SPECIFIC GRAVITY/ABSORPTION, COARSE AGGREGATE	–	–	6/2	–/–
AGGREGATES	C128	SPECIFIC GRAVITY/ABSORPTION, FINE AGGREGATE	–	–	–/–	3/1
AGGREGATES	C131	RESISTANCE TO ABRASION, LOS ANGELES MACHINE	–	–	1	–
AGGREGATES	C136	SIEVE ANALYSIS, COARSE AND FINE AGGREGATE	–	–	2	2
AGGREGATES	C295	PETROGRAPHIC EXAM. OF AGGREGATES FOR CONCRETE	–	–	1	1
CONCRETE	C39	COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS	–		24	
CONCRETE	C138	UNIT WEIGHT, YIELD, AIR CONTENT OF CONCRETE	–		3	
CONCRETE	C143	SLUMP OF PORTLAND CEMENT CONCRETE	–		4	
CONCRETE	C157	LENGTH CHANGE OF HARDENED CEMENT MORTAR AND CONCRETE	–		30	
CONCRETE	C173	AIR CONTENT OF CONCRETE, VOLUMETRIC METHOD	–		3	
CONCRETE	C192	MAKING AND CURING CONCRETE SPECIMENS	–		3	
CONCRETE	C227	POTENTIAL ALKALI-SILICA REACTIVITY, MORTAR-BAR METHOD	–	–	–	1 (IP)
CONCRETE	C469	STATIC MODULUS OF ELASTICITY, POISSONS RATIO OF CONCRETE IN COMPRESSION	–		24	
CONCRETE	C496	SPLITTING TENSILE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS	–		6	
CONCRETE	C684	MAKING AND TESTING ACCELERATED CURE CONCRETE COMPRESSION TEST SPECIMENS	–		6	
CONCRETE	222-1-77[2]	SELECTING PROPORTIONS FOR NORMAL AND HEAVY WEIGHT CONCRETE	–		3	
CONCRETE	PROP.[3]	POTENTIAL ALKALI-CARBONATE ROCK REACTIVITY, LENGTH CHANGE METHOD	–		–	
CONCRETE	C39-55[4]	COEFFICIENT OF LINEAR THERMAL EXPANSION OF CONCRETE	–		6 (IP)	

1. AMERICAN SOCIETY FOR TESTING AND MATERIALS (1978)
2. AMERICAN CONCRETE INSTITUTE (1977)
3. MIELENZ (1980) PROPOSED ASTM STANDARD TEST
4. UNITED STATES ARMY CORPS OF ENGINEERS (1977)

(IP) - TEST IN PROGRESS

* BASIN-FILL SOURCES SUPPLIED BOTH COARSE AND FINE AGGREGATES FOR CONCRETE MIX. LEDGE ROCK SOURCES SUPPLIED COARSE AGGREGATES; LOCAL SAND SOURCES (GENERALLY COLLECTED WITHIN A FEW MILES OF CORRESPONDING LEDGE ROCK SOURCES) SUPPLIED FINE AGGREGATES FOR CONCRETE MIX.

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AGGREGATE AND TRIAL MIX TESTS
CONCRETE AGGREGATES EVALUATION
MULESHOE VALLEY, NEVADA

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TABLE 1

CONCRETE CONSTITUENTS AND PROPERTIES	CONCRETE TRIAL MIX DESIGN CRITERIA					
	MIX 1 7.5/1.5 IN.[1]		MIX 2 8.5/1.5 IN.[1]		MIX 3 8.5/0.75 IN.; SUPER.[1]	
	VOLUME	WEIGHT	VOLUME	WEIGHT	VOLUME	WEIGHT
CEMENT, NEVADA TYPE II (LOW ALKALI; FT^3, LBS)	2.87	564	3.26	639	3.26	639
FLY ASH, WESTERN (REPLACES 20% OF CEMENT BY WEIGHT; FT^3, LBS)	0.99	141	1.12	160	1.12	160
SUPERPLASTICIZER (WRDA 19; OZ/CWT)[2]	—	—	—	—	15	—
WATER REDUCER (WRDA 79; OZ/CWT)	5	—	5	—	5	—
AIR ENTRAINMENT ADMIXTURE (DARAVAIR: OZ/CWT [FT^3])	1.5 [1.08]	—	1.5 [1.08]	—	1.5 [1.08]	—

SLUMP, MAXIMUM (INCHES)	3 - 4	3 - 4	0 - 1[3]
AIR CONTENT, RANGE (PERCENT)	4 - 6	4 - 6	4 - 6
WATER/CEMENT RATIO (BY WEIGHT)	0.36	0.32	0.33
CEMENT FACTOR (SCY)[4]	7.5	8.5	8.5

1. SACKS OF CEMENT PER CYD / MAXIMUM AGGREGATE SIZE
2. OZ/CWT = OUNCES/100 POUNDS OF CEMENT AND FLY ASH
3. SLUMP BEFORE ADDITION OF SUPERPLASTICIZER
4. SCY = SACKS OF CEMENT/CUBIC YARD OF CONCRETE

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CONCRETE TRIAL MIX DESIGN CRITERIA
MULESHOE VALLEY, NEVADA

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TABLE 2

o Air Content of Concrete, Volumetric Method;

o Making and Curing Concrete Specimens;

o Making and Testing Accelerated Cure Concrete Compression Test Specimens; and

o Selecting Proportions for Normal and Heavyweight Concrete.

Hardened Properties

o Compressive Strength of Cylindrical Concrete Specimens;

o Length Change of Hardened Cement Mortar and Concrete;

o Potential Alkali-Silica Reactivity, Mortar-Bar Method;

o Static Modulus of Elasticity of Concrete in Compression;

o Splitting Tensile Strength of Cylindrical Concrete Specimens;

o Potential Alkali-Carbonate Rock Reactivity, Length Change Method; and

o Coefficient of Linear Thermal Expansion of Concrete.

The results of all tests summarized in Table 1 are important to the concrete aggregates evaluation, but hardened concrete properties are considered the most significant (see Section 4.1.1, Requirements for Concrete Aggregates). Although the primary requirement for concrete is a 28-day compressive strength of 6500 psi, one-day (accelerated), seven-day, and 90-day tests were done to determine the range of compressive strength values. In order to compare different aggregate sources, 28-day compressive strengths of Mix 3 were always used.

Occasionally, fresh concrete properties varied from design concrete specifications and may have affected hardened concrete test results. If known or significant, the causative factor and

its effect on test results are mentioned in the discussions on sources of concrete aggregates (Sections 4.2.2).

The scope of the study did not allow sample collection and laboratory testing of all potential basin-fill and rock concrete aggregate sources. Existing data and field petrographic and grain-size analyses were used to correlate lithologic and gradation properties to basin-fill units which were not sampled. An important element of this correlation procedure was the use of aerial photography to help delineate the lateral extent of basin-fill deposits. Photogeologic field observations ascertained geomorphological and topographical relationships of basin-fill units and the source rock lithology and distribution of predominantly gravelly materials.

Limited laboratory and field data prevented most correlations of data from tested to untested rock units. Potential aggregate sources were confined to the limits of tested or correlated outcrops as determined from existing data, limited photogeological interpretation, and field reconnaissance.

4.1.3 Presentation of Results

Results of the concrete aggregates evaluation are presented in the form of text, tables, figures, 1:62,500 scale drawings, and appendices. Drawing 1 is a location map showing the position in the study area of all data points used in the Detailed Aggregate Resources Study. All data points are grouped by study type and assigned categorized map numbers (see Section 3.1.3).

Drawing 3 presents the locations of the potential concrete aggregate sources, the basin-fill source of fine aggregate that was mixed with crushed rock, DARS trenches, select VSARS data stops, and field petrographic and grain-size data stops in the study area. Geologic unit symbols used in Drawing 3 relate to standard geologic nomenclature whenever possible. A conversion table relating these symbols to the geologic unit nomenclature used in other Ertec reports is contained in Appendix Table F-3.

A solid contact line separates basin-fill and rock units in Drawing 3 to differentiate these two basic material types. All rock contacts are taken from published data or limited air-photo interpretation and are dashed. Basin-fill contacts are derived from photogeological mapping with limited field reconnaissance and are also dashed.

Classifications of potential basin-fill and rock concrete aggregate sources are distinguished by different patterns. Patterns for basin-fill and rock sources of the same classification are similar, with the basin-fill pattern emphasized by a dark background tone.

The appendices contain tables that summarize the basic field data collected during the course of the study and the subsequent laboratory test procedures and results. Appendices A and B contain DARS trench data and petrographic and grain-size data, respectively. Appendix C contains representative trench logs. Appendix Table D-2 presents a laboratory testing flow diagram for the concrete aggregates evaluation. Appendix E presents the

chemical analyses of cement, fly ash, and water used in making all concrete trial mixes. Appendix F includes three tables describing soil classification, caliche development, and geologic unit cross reference.

4.1.4 Classification of Concrete Aggregates

A classification system was designed to present the most likely basin-fill and crushed-rock concrete aggregate sources. It was developed from an evaluation as well as from an extrapolation of all available data. Data include laboratory test results (compressive strength of concrete and grain-size, abrasion, and soundness of aggregates) and geomorphological and compositional correlations.

The classification system groups potential aggregate sources into three categories:

1. Aggregate sources which were used in concrete mixes - Class CA1 and Class CA2;
2. Aggregate sources which were subjected to basic aggregate tests - Class CB; and
3. Untested aggregate sources which were correlated to Classes CA1, CA2, or CB - Class CC1 and Class CC2.

The classification is presented in hierarchy form; classification of the highest potential source areas is described first, and classification of the lowest potential source areas is described last.

Class	Explanation
CA1	Basin-fill or rock sources containing aggregates that produced trial

	mix concrete with 28-day compressive strengths equal to or greater than 6500 psi using Mix 3 (Section 4.1.2).
CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi using Mix 3 (Section 4.1.2).

The Classes CA1 and CA2 describe those specific sources where basin-fill or crushed-rock aggregates have been collected and used in making trial mix batches of concrete. Following appropriate ASTM standards, concrete cylinders containing the collected aggregates were made, cured, and tested for various hardened concrete properties. The class is divided into two categories by 28-day compressive strength test results.

Generally, aggregates from each potential source area have been tested previously during the VSARS program. Confirmation testing that included abrasion and soundness tests was performed when applicable to ensure the continued acceptability of a sample for use in concrete. Abrasion and $MgSO_4$ soundness values do not exceed coarse aggregate requirements specified in Section 4.1.1. A tested sample of the fine aggregate used in the concrete trial mixes had a $MgSO_4$ soundness loss exceeding the required 15 percent maximum and a $NaSO_4$ soundness loss exceeding the 10 percent maximum.

Class	Explanation
CB	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on acceptable laboratory aggregate test results.

The Class CB describes those source areas that have been sampled and tested only for grain-size gradation, abrasion, and magnesium sulfate soundness. Trial concrete mixes were not made. Gradation, abrasion, and soundness values specified in Section 4.1.1 were used to assign this classification to an aggregate source.

Class	Explanation
CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 or CA2 areas.
CC2	Basin-fill sources of aggregates potentially suitable for use in concrete; based on correlation with Class CB areas.

Untested Class CC deposits are correlated to tested Class CA or CB deposits on the basis of field observations and limited field and laboratory test results. Class CC basin-fill deposits consist of units of the same apparent relative age as Class CA and CB deposits. Class CC1 rock deposits are additional nearby outcrops of the same unit as Class CA deposits.

Field observations and petrographic and grain-size analyses provided correlative data on lithology of adjacent source rock and lithology and general amounts of gravel present in the basin-fill units. Photogeologic interpretations were also used to correlate Class CC basin-fill deposits to Class CA or CB basin-fill deposits. Specific geomorphological parameters correlated during the procedure included surface texture, drainage patterns, relative relief, and topographic profiles.

All classifications are based on limited data. Additional field reconnaissance, testing, and case history studies are needed to confirm adequacy, delimit exact areal boundaries, and refine chemical and physical properties.

4.2 SOURCES OF CONCRETE AGGREGATES

4.2.1 Basin-Fill Sources

Basin-fill sources of concrete aggregates are grouped into two classes. Deposits defined on the basis of laboratory test data are included in Class CB. Untested basin-fill deposits correlated to deposits with test data are included in Class CC2.

4.2.1.1 Class CB

Class CB basin-fill aggregate sources are alluvial deposits that have been sampled and laboratory tested and, on the basis of the test results, are considered to be potential concrete materials sources. Class CB aggregates have not been used in trial concrete mixes. Test results show that these deposits contain at least 30 percent gravel clasts of all sizes (3-inch to No. 4 sieve), have less than 50 percent abrasion wear, and, where applicable, have less than 18 percent loss when subjected to a $MgSO_4$ soundness test.

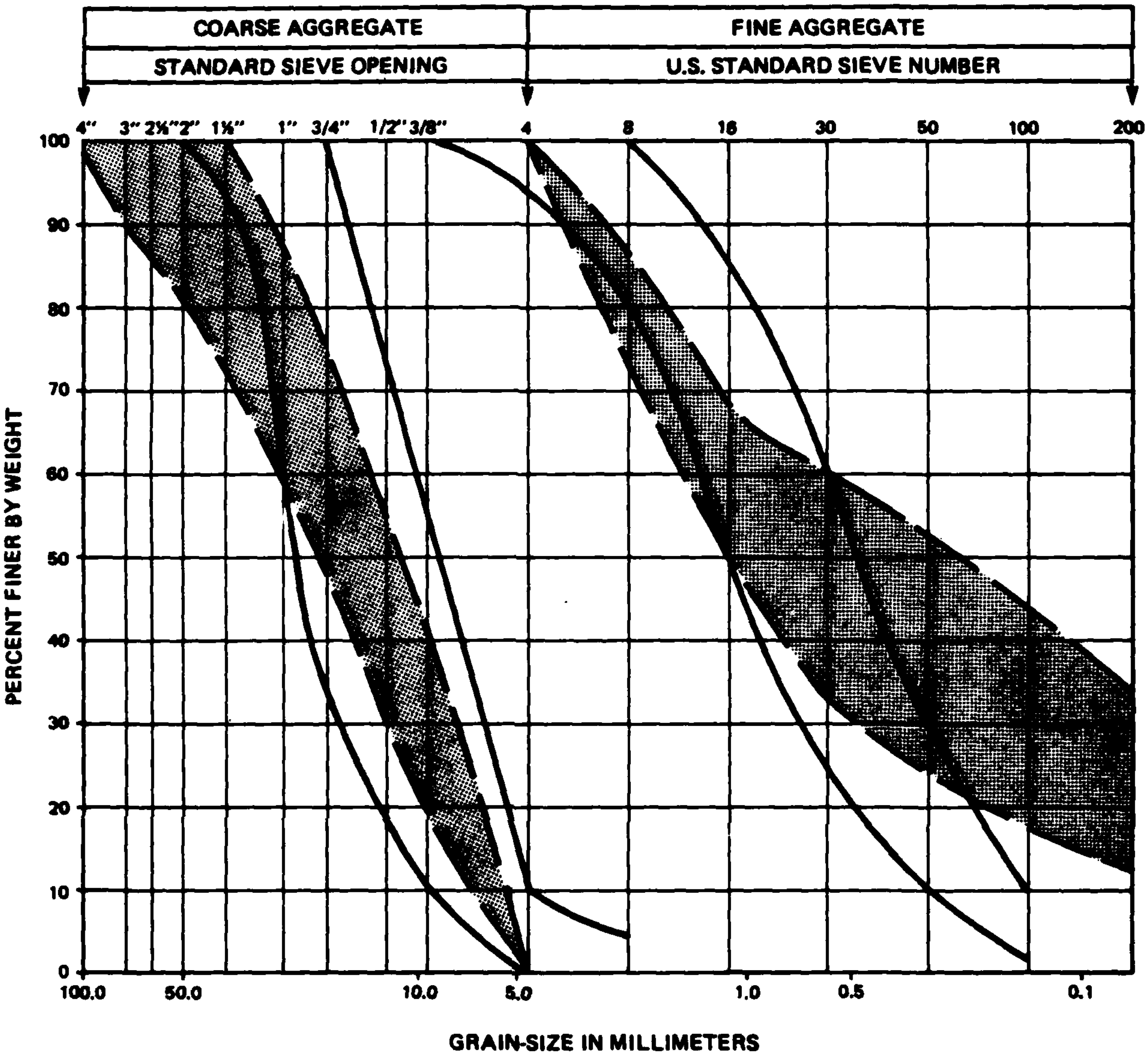
There are three Class CB sources within the study area located adjacent to Dutch John Mountain, Grassy Mountain, and the Schell Creek Range. All are alluvial fan deposits (Aaf).

Class CB alluvial fan deposits generally consist of poorly to well-graded, subangular to subrounded sandy gravel and gravelly

sand. The gravel content of Class CB deposits ranges from 28 to 56 percent, the sand content ranges from 19 to 37 percent, and the silt and clay content ranges from nine to 20 percent. The two Class CB deposits located in the southwest and northeast parts of the valley are composed predominantly of carbonate clasts with some quartzite clasts and a minor amount of volcanic clasts. The east-central deposit differs from the other two Class CB deposits in that it contains predominantly volcanic clasts with a lesser amount of carbonate clasts.

The percentages of coarse aggregates passing the 1-inch to No. 4 sieve sizes conforms to design gradation requirements (Figure 5). The percentages of coarse gravel passing the 2- to 1.5-inch sieves is deficient. There is oversize material available that, when crushed, will provide additional aggregates of all sizes. The percentage of fine aggregate passing the No. 4 to No. 8 sieves is deficient and the percentage of fine aggregates passing the No. 50 to No. 100 sieves is excessive. Variations in grain-size gradation will occur within the deposit depending on proximity to the source area. In general, the deposits are relatively finer grained near the valley axis and coarser grained near the mountain fronts.

Laboratory abrasion tests performed on samples from all Class CB units resulted in a fairly narrow range of values, 25.5 to 34.5 percent wear. A laboratory $MgSO_4$ soundness test performed on the northeastern deposit resulted in a 6.6 percent loss for the coarse aggregates and a 26.5 percent loss for the fine aggregates.



REQUIRED GRAIN-SIZE DISTRIBUTION ENVELOPES FOR COARSE AND FINE AGGREGATES USED IN CONCRETE (AMERICAN SOCIETY FOR TESTING AND MATERIALS, 1978, C 33; THE RECOMMENDED GRADATIONS FOR AGGREGATES WITH 1.5 AND 0.75 INCH MAXIMUM SIZE ARE COMBINED INTO ONE ENVELOPE).

GRAIN-SIZE DISTRIBUTION ENVELOPES OF BASIN—FILL COARSE AND FINE AGGREGATES POTENTIALLY SUITABLE FOR CONCRETE.

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GRAIN-SIZE DISTRIBUTION ENVELOPES
CONCRETE AGGREGATES, CLASS CB
MULESHOE VALLEY, NEVADA

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FIGURE 5

The areal extent of Class CB deposits ranges from 2.1 to 4.4 mi^2 (5.4 to 11.4 km^2). It is estimated that the material sampled from these deposits extends to a depth of 25 feet (7.6 m) and will have a yield of 60 to 80 percent.

4.2.1.2 Class CC2

Class CC2 basin-fill aggregate sources are alluvial fan deposits that have been correlated to Class CB concrete aggregate deposits on the basis of geomorphological and compositional similarities. Class CC2 deposits are therefore assumed to contain material similar in size and composition to Class CB deposits. These deposits are located on both sides of the valley adjacent to the Class CB basin-fill deposits. The areal extent of the four Class CC2 deposits range from 1.4 to 7.8 mi^2 (3.6 to 20.2 km^2).

4.2.2 Rock Sources

Rock concrete aggregate sources are grouped into three classes. Rock defined on the basis of laboratory test data are included in Classes CA1 and CB. Class CC1 contains rocks correlated to tested rock units.

4.2.2.1 Class CA1

One Class CA1 crushed-rock coarse aggregate source was delineated within the study area. This rock source is located on the east side of the study area and comprises a large area of Dutch John and Grassy mountains. Class CA1 rocks belong to the undifferentiated carbonate rock unit (Cau) and were sampled during the present study. The fine aggregate used in conjunction with

the Class CA1 rock is from a basin-fill unit located approximately 4 miles (6.4 km) west of the CA1 rock unit.

The Class CA1 rock sample used in the concrete trial mix consisted of dark-gray to black, microcrystalline to aphanitic limestone. When crushed, these rocks produce fragments that are generally angular and equidimensional to thick-tabular in shape.

Approximately 80 percent of the crushed-rock fragments are of satisfactory physical quality; approximately 18 percent are internally fractured and porous and of fair physical quality; and about one percent are highly clayey and of poor quality. No sampled rock fragments were found to be susceptible to the alkali-silica or alkali-carbonate rock reactions.

The sand used in conjunction with the Class CA1 rock source was collected from an alluvial fan deposit (Aaf) which consists of poorly graded, subangular to angular gravelly sand. Approximately 36 percent of the sand particles are of satisfactory physical quality; 57 percent are moderately weathered or internally fractured and are of fair quality; and seven percent are soft, highly porous particles of calcerous coating material and are of poor quality. The sand is composed of approximately 79 percent dolomite and limestone, nine percent quartz, three percent volcanics, and nine percent coating material.

The limestone and dolomitic limestones within the sand may be susceptible to a deleterious degree to the alkali-carbonate reaction. The volcanic constituents in the sand may be susceptible to a deleterious degree to the alkali-silica reaction.

The crushed-rock aggregates from the Class CA1 deposit were subjected to a laboratory abrasion test which yielded a result of 33.3 percent wear. A $MgSO_4$ soundness test performed on the crushed rock yielded a result of 2.2 percent loss. These results are well within the maximum allowable values for abrasion wear and soundness loss for coarse aggregate concrete construction materials. The fine aggregate used in conjunction with the crushed rock failed the $MgSO_4$ soundness test with a result of 41.4 percent loss and also failed the $NaSO_4$ test with a 17.1 percent loss.

A 28-day compressive strength of 7100 psi was obtained from concrete trial Mix 3 using Class CA1 crushed rock (Table 3). This same mix produced a 90-day compressive strength of 8865 psi. Concrete Mixes 1 and 2, using Class CA1 crushed rock, produced 28-day compressive strengths of 4920 psi and 4875 psi, respectively. The lower strength of Mix 2 at 28 days may be due to a high relative yield value. Fresh concrete properties and hardened concrete test results (chord modulus of elasticity, splitting tensile strength, drying shrinkage) are also included in Table 3. Test results for hardened concrete are generally within the required limits stated in Section 4.1.1.

4.2.2.2 Class CB

Class CB crushed-rock sources are rock units that have been sampled and laboratory tested and, on the basis of the test results, are considered to be potential concrete aggregate sources. Class CB rocks have not been used in concrete trial mixes.

AGGREGATE SOURCE[1]	FIELD STATION	CONCRETE MIX DESIGN CRITERIA[2] SACKS OF CEMENT/CYD / MAX. AGG. SIZE	FRESH CONCRETE PROPERTIES SLUMP[3] (IN.)	AIR CONTENT (%)	UNIT WEIGHT (PCF)	WATER/ CEMENT RATIO	CEMENT FACTOR (SCY)	ASTM STANDARD TE
LEDGE-ROCK AND SAND	MS-R-1 & MS-FA-1	MIX 1 7.5/1.5 IN.	3.25	7.0	142.0	0.36	7.32	COMPRESSIVE STRENGTH, A (PSI) CHORD MODULUS OF ELASTICIT (PSI x 10[6]) SPLITTING TENSILE STRENGTH (PSI) DRYING SHRINKAGE, AST (PERCENT)
	MS-R-1 & MS-FA-1	MIX 2 8.5/1.5 IN.	2.5	4.5	139.4	0.34	8.08	COMPRESSIVE STRENGTH, A (PSI) CHORD MODULUS OF ELASTICIT (PSI x 10[6]) SPLITTING TENSILE STRENGTH (PSI) DRYING SHRINKAGE, AST (PERCENT)
	MS-R-1 & MS-FA-1	MIX 3 8.5/0.75 IN., SUPER-PLASTICIZER	0 BEF. 5.5 AFT.	4.5	143.8	0.31	8.46	COMPRESSIVE STRENGTH, A (PSI) CHORD MODULUS OF ELASTICIT (PSI x 10[6]) SPLITTING TENSILE STRENGTH (PSI) DRYING SHRINKAGE, AST (PERCENT)

1. BASIN-FILL SOURCES SUPPLIED BOTH COARSE AND FINE AGGREGATES FOR CONCRETE MIX. LEDGE-ROCK SOURCES SUPPLIED COARSE AGGREGATES; LOCAL SAND SOURCES (GENERALLY COLLECTED WITHIN A FEW MILES OF CORRESPONDING LEDGE-ROCK SOURCES) SUPPLIED FINE AGGREGATES FOR CONCRETE MIX.
2. ASTM AND ACI SPECIFICATIONS AND PROCEDURES WERE FOLLOWED IN THE MIX DESIGN AND BATCHING OF THE CONCRETE TRIAL MIXES. THE CONCRETE MIXES CONSISTED OF COARSE AND FINE AGGREGATES, LOW ALKALI CEMENT, FLY ASH (20% BY WEIGHT REPLACEMENT OF CEMENT), SUPERPLASTICIZER, AIR-ENTRAINING ADMIXTURE, AND WATER REDUCER.
3. BEF. – SLUMP BEFORE ADDITION OF SUPERPLASTICIZER.
   AFT. – SLUMP AFTER ADDITION OF SUPERPLASTICIZER.
4. COMPRESSIVE AND TENSILE STRE CYLINDERS. DRYING SHRINKAGE MENS; TIMETABLE INCLUDES A S

HARDENED CONCRETE TEST RESULTS

ASTM STANDARD TEST 4	TIMETABLE				
	1 DAY (ACCELERATED)	7 DAYS	28 DAYS	90 DAYS	
…PRESSIVE STRENGTH, ASTM C 39 (PSI)	2265	3615	4920	5830	
…ODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	2.59	3.45	3.82	4.06	
…NG TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	430	—	
…YING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.040	0.062	0.070	0.072
…PRESSIVE STRENGTH, ASTM C 39 (PSI)	2220	3485	4875	5630	
…ODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	2.80	3.47	3.74	4.11	
…NG TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	410	—	
…RYING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.028	0.045	0.047	0.049
…MPRESSIVE STRENGTH, ASTM C 39 (PSI)	3020	5660	7100	8865	
…ODULUS OF ELASTICITY, ASTM C 469 (PSI x 10^6)	2.80	3.32	4.29	4.34	
…NG TENSILE STRENGTH, ASTM C 496 (PSI)	—	—	490	—	
…RYING SHRINKAGE, ASTM C 157 (PERCENT)	7 DAYS	14 DAYS	21 DAYS	28 DAYS	35 DAYS
	0.00	0.031	0.051	0.060	0.066

…SSIVE AND TENSILE STRENGTH VALUES ARE AVERAGES OBTAINED FROM TWO TESTED …ERS. DRYING SHRINKAGE VALUES ARE AVERAGES OBTAINED FROM TWO TESTED SPECI- …TIMETABLE INCLUDES A SEVEN DAY MOIST CURE.

Ertec
The Earth Technology Corporation

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

CONCRETE TRIAL MIX TEST REULTS
MS-R-1 AND MS-FA-1
MULESHOE VALLEY, NEVADA

5 JUN 81 TABLE 3 1 OF 1

2

The Class CB rock source within the study area is located in the Schell Creek Range and is an undifferentiated carbonate rock (Cau). The sampled interval consists of a fairly extensive outcrop of dark-gray, hard, medium-grained, thinly bedded limestone.

A laboratory abrasion test performed on the Class CB crushed rock yielded a result of 35.2 percent wear. When subjected to a magnesium sulfate soundness test, the crushed rock exhibited a 5.6 percent loss. These results are well below the maximum allowable abrasion wear of 50 percent and soundness loss of 18 percent for coarse aggregate used as concrete construction material.

4.2.2.3 Class CC1

Class CC1 potential concrete aggregate sources are untested rock outcrops of the undifferentiated carbonate rock geologic unit (Cau). Published geologic maps were used to delineate outcrops. These sources are part of the same geologic unit as the Class CA1 source and have essentially the same limestone lithology.

5.0 CONCLUSIONS

Results of the Detailed Aggregate Resources Study indicate that there are sufficient quantities of aggregates available for the construction of the MX missile system in the Muleshoe Valley study area.

Good- to high-quality basin-fill and crushed-rock coarse aggregates are present on both sides of the valley. Sufficient quantities of poor- to fair-quality fine aggregates are present in basin-fill deposits in the valley. After shelter layouts are finalized, potential borrow areas can be delineated based on the results of this study.

Although most rock will supply acceptable coarse aggregates, limited sources are delineated in this study. Sufficient quantities of basin-fill aggregates within the valley will probably make processing of crushed-rock aggregates unnecessary.

As discussed in the report, field studies placed an arbitrary cut-off limit of a minimum of 30 percent gravel for the source to be considered for road-base or concrete aggregates. Nevertheless, basin-fill deposits with less than 30 percent gravel are also probably potentially suitable for use as aggregates. However, yield from such sources will be low, and extensive processing and/or blending will be required to satisfy the gradation requirements.

5.1 ROAD-BASE AGGREGATES

5.1.1 Class RBIa Sources

Three basin-fill deposits consisting of good- to high-quality aggregates acceptable for road base have been located within the study area. These deposits are alluvial fan units and have a total areal extent of approximately 10 mi^2 (26 km^2).

Gradation results indicate that, where sampled, the deposits approximate ASTM standards and DARS requirements. Sand and fine gravel sizes are within design gradation requirements. In some cases, gravels passing the 1.5- to 1-inch sieves are deficient. Crushing and blending the oversize materials will produce additional aggregates of all sizes. In addition, grain-size variations will occur depending on sample location within the deposit. Generally, finer grained material can be obtained nearer the valley axis and coarser grained material can be obtained near mountain front source areas.

Abrasion and soundness results on tested samples are also within ASTM standards and DARS requirements.

Two good- to high-quality coarse aggregate crushed-rock sources, which are acceptable for use as road-base aggregates, have been delineated within the study area. These sources are fairly extensive outcrops of undifferentiated carbonate rocks (Cau). Samples from these rock sources yielded test results for gradation, abrasion, and soundness well within acceptable ranges as specified by ASTM standards and DARS requirements.

5.1.2 Class RBIb Sources

Four basin-fill deposits within the study area are defined as potential sources of good- to high-quality aggregates for use as road-base construction material. Geomorphological and compositional similarities were used to correlate these deposits to tested RBIa deposits. All the deposits are alluvial fans (Aaf). Their total areal extent is approximately 14.7 mi^2 (38.1 km^2).

5.1.3 Class RBII Sources

Several potential road-base aggregate sources defined by limited field and laboratory data are present throughout the study area. All deposits are alluvial fans, consist predominantly of sandy gravel or gravelly sand and are compositionally similar to Class RBIa and RBIb deposits. These deposits have a total areal extent of approximately 17.5 mi^2 (45.3 km^2).

5.2 CONCRETE AGGREGATES

5.2.1 Class CA1 Sources

One Class CA1 rock source (Cau) was delineated on the east side of the study area. The crushed-rock coarse aggregates from this source have acceptable abrasion and soundness test results, but the local sand (fine aggregates) used in the mix had high $MgSO_4$ and $NaSO_4$ soundness losses.

5.2.2 Class CB Sources

Three basin-fill deposits consisting of good to high quality coarse aggregates potentially suitable for use as concrete construction material were delineated within the study area.

These deposits are all alluvial fan units (Aaf). Their total areal extent is approximately 10 mi^2 (26 km^2). No concrete trial mixes were made, but gradation, abrasion, and soundness test results on samples of coarse aggregates from these deposits were well within acceptable ranges as specified by ASTM standards and DARS requirements. However, fine aggregates generally did not meet $MgSO_4$ soundness test requirements.

5.2.3 Class CC1 Sources

Several Class CC1 crushed-rock aggregate sources have been delineated in the study area. These sources have lithologic similarities to the Class CA1 rock source.

5.2.4 Class CC2 Sources

Four alluvial fan units located within the valley are classified as potential sources of concrete aggregates. Units were correlated to Class CB sources on the basis of geomorphological and compositional similarities. They have a total areal extent of approximately 14.7 mi^2 (38.1 km^2).

6.0 RECOMMENDATIONS FOR FUTURE STUDIES

The conclusions of this Detailed Aggregate Resources Study of Muleshoe Valley, as enumerated in Section 5.0, are based on limited field and laboratory test results. However, the results presented in this report provide sufficient data for selecting potential borrow areas. After selection of the borrow areas, more extensive studies are required to further determine the characteristics of the aggregates.

6.1 SOURCES OF ROAD-BASE AGGREGATES

It is recommended that additional field exploration (backhoe or drilling) and detailed laboratory testing be performed. The laboratory tests should consist of sieve analysis, resistance to abrasion, CBR, and other appropriate tests as deemed necessary by the designers.

6.2 SOURCES OF CONCRETE AGGREGATES

It is recommended that additional field investigations (backhoe or drilling) and detailed laboratory testing be performed. The aggregate samples should be subjected to the following tests:

- o Sieve Analysis;
- o Resistance to Abrasion;
- o Soundness;
- o Specific Gravity and Absorption; and
- o Petrographic Examination of Aggregates for Concrete.

In addition, the following detailed tests using concrete made from these aggregates should be performed:

- o Compressive Strength;
- o Splitting Tensile Strength;
- o Flexural Strength;
- o Shrinkage;

- o Thermal Expansion;
- o Modulus of Elasticity;
- o Potential Alkali-Silica Reactivity;
- o Potential Alkali-Carbonate Rock Reactivity; and
- o Resistance of Concrete to Rapid Freezing and Thawing.

It is also recommended that concrete trial mixes with different size aggregates and admixtures be made in order to assess the variation in compressive strength, durability, shrinkage, and thermal properties of concrete.

In-progress Verification studies (E-TR-27-MS-I and II) performed in Muleshoe Valley indicate that potential for sulfate attack of soils on concrete is "negligible." However, it is recommended that additional studies be made to further evaluate the potential for sulfate attack of soils on concrete and to determine the type of cement to be used in concrete.

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Polivka, Milos, 1981, Consulting Civil Engineer, Berkeley, California.

APPENDIX A

SUMMARY OF FIELD AND LABORATORY TEST DATA

FIELD AND LABORATORY TEST DATA

Field observations and laboratory test data on samples collected at selected stations are presented in Table A-1. Field stations were established at various locations throughout the study area where detailed descriptions of potential basin-fill, fine aggregate, and crushed-rock sources were recorded. Detailed explanations for the column headings of Table A-1 are as follows:

COLUMN HEADING	EXPLANATION
MAP NUMBER	Map numbers are sequentially arranged identifiers of field stations occupied during the course of the aggregate study.
FIELD STATION	These designations are internal DARS identifiers of all field stations. Each one consists of a two-letter valley abbreviation followed by the letter A (aggregate trench), FA (fine aggregate trench), or R (ledge rock).
LOCATION	The location column lists the geographic portion of the valley in which the field station is located (e.g., NE-northeast).
GEOLOGIC UNIT	The geologic unit listed is a term used to differentiate basin-fill deposits based on geomorphology and rock units based on existing geologic maps. A geologic unit cross reference, outlining all units used, is included as Table F-3.
MATERIAL DESCRIPTION	Material descriptions are based on either field or laboratory USCS classifications using appropriate ASTM standards for basin-fill deposits and existing references and Travis (1955) for rock units. Coarse and fine aggregate gradations used in concrete trial mix designs are included at the end of each concrete aggregate trench group.
USCS SYMBOL	Appropriate field or laboratory ASTM standards are used to classify sampled

material. The Unified Soil Classification System is used in this study. Table F-1 contains detailed information on the USCS.

FIELD OBSERVATIONS

Boulders and/or Cobbles — The estimated occurrence of boulders and cobbles is based on an appraisal of the entire deposit. Cobbles have an intermediate diameter of 3 to 12 inches (8 to 30 cm); boulders have an intermediate diameter of 12 inches (30 cm) or more. Because of sample-size limitations, boulders were not generally sampled. Cobbles were representatively sampled for concrete aggregate evaluations but only generally sampled for road-base aggregate evaluations. Field observations of boulders and cobbles are important considerations for in-situ gradations only. Number percentages are equated to the following equivalent dry weight terms:

Rare	-	1 - 4 percent
Few	-	5 - 20 percent
Some	-	> 20 percent

Gravel — Coarse aggregate particles that pass a 3-inch (76-mm) sieve but are predominantly retained on a No. 4 (4.75 mm) sieve.

Sand — Fine aggregate particles that almost entirely pass a No. 4 sieve but are predominantly retained on a No. 200 (0.075 mm) sieve.

Fines — Soil particles that pass a No. 200 sieve (silt and clay).

Overburden Thickness (Feet) — Surficial soil overlying a usable aggregate deposit. Material generally consists of silt and sand with low concentrations of gravel. Numbers presented indicate thickness of deposit in feet.

Total Trench Depth (Feet) — Depth, in feet, of trench excavation used to collect aggregate samples. Depth followed by the letter R indicates that depth below which soil strength exceeded excavation capability. The common conditions for refusal (R) are calcium carbonate accumulation (caliche) and/or presence of oversized material.

Deleterious Materials (Material/Depth/ Stage)	Deleterious materials are substances that are potentially detrimental to concrete in service. Substances that may be present include: organic impurities, low density materials (ash, vesicles, pumice, cinders), amorphous silica (opal, chert, chalcedony), volcanic glass, caliche and clay coatings, mica, gypsum, pyrite, chlorite, friable materials, and aggregates that may react chemically or be affected chemically by other external influences. The most common deleterious material is calcium carbonate accumulation (caliche). When it is abundant, the interval(s) at which it occurs and the stage of development (Table F-2) are listed. Caliche can occur disseminated throughout a deposit, as lenses, and as discrete layers. The depth space is left blank when caliche is present throughout the deposit.
Plasticity (Index)	Plasticity index (PI) is the range of water content, expressed as a percentage of the weight of the oven-dried soil (less than No. 40 sieve material), through which a soil behaves plastically . It is defined as the liquid limit minus the plastic limit. Field terms used to approximate plasticity index range include the following.

Plasticity	PI	Wet Consistency
Slight	(4-15)	Slightly sticky; after pressure, soil adheres to both thumb and finger but comes off cleanly. Does not appreciably stretch.
Medium	(15-30)	Sticky; after pressure, soil adheres to both thumb and finger and tends to stretch somewhat before pulling apart from either digit.
High	(>30)	Very sticky; after pressure, soil adheres strongly to both digits and is markedly stretched when digits are separated.

Hardness	Hardness determination is a field test used to identify materials that are soft or poorly bonded by estimating their resistance to crushing by impact with a

	rock hammer. Classification terms used include:
Soft	Hammer point indents deeply with firm blow.
Moderately Hard	Hammer point indents only shallowly with firm blow.
Hard	Hammer breaks hand-held sample with one firm blow.
Very Hard	Hammer breaks intact sample with many blows.
<u>Weathering</u>	Weathering is defined as any changes in color, texture, strength, chemical composition, or other properties of rock due to the effects of various atmospheric conditions. Field terms used to classify degree of weathering include: fresh, slight(ly), moderate(ly), or very weathered.

LABORATORY TEST DATA

<u>Sieve Analysis (ASTM C 136)</u>	A sieve analysis is the determination of the proportions of particles existing within certain size ranges in granular material by separation on sieves of different size openings, expressed as a weight percent of the total sample. Numbers presented represent the percent of the sample passing through the stated sieve size. Sieve sizes include: 3-inch (75-mm), 2 1/2-inch (63-mm), 2-inch (50-mm), 1 1/2-inch (38.1-mm), 1-inch (25-mm), 3/4-inch (19-mm), 1/2-inch (12.5-mm), 3/8-inch (9.5-mm), No. 4 (4.75 mm), No. 8 (2.36 mm) No. 16 (1.18 mm) No. 30 (0.6 mm), No. 50 (0.3 mm), No. 100 (0.15 mm), No. 200 (0.075 mm).
<u>Specific Gravity and Absorption (ASTM C 127 and 128)</u>	In general, specific gravity is defined as the ratio of the weight in air of a unit volume of material to the weight in air of an equal volume of water. Absorption is the process by which a liquid is drawn into and tends to fill permeable pores in a porous solid body, also, the increase in weight of a porous

solid body resulting from the penetration of a liquid into its permeable pores. Specific definitions of bulk, bulk saturate-surface-dry (SSD), and apparent specific gravity, as well as absorption are contained in ASTM-E 12-70 and C 125, respectively.

Fineness Modulus

Fineness modulus is an empirical factor obtained by adding the total percentages of a sample of aggregate, retained on each of a specified series of sieves, and dividing the sum by 100.

Unit Weight

Unit weight is the weight of a unit volume of dry, rodded aggregate, commonly expressed as pounds per cubic foot (pcf).

Abrasion Test (ASTM C 131)

The abrasion test is a method for testing resistance to wearing away by rubbing and friction, by placing a specified quantity of aggregates in a steel drum (the Los Angeles testing machine), rotating the drum 500 times, and determining the percent of material worn away.

Soundness Test (ASTM C 88)

Soundness tests are used to determine resistance to large or permanent volume changes of aggregates by placing samples in saturated solutions of magnesium or sodium sulfate. The test furnishes information useful in studying resistance to weathering action, particularly when adequate service records of the material tested are not available. For concrete aggregate tests, magnesium sulfate soundness tests are run first. If the material fails this test, sodium sulfate soundness tests are performed.

Petrographic Examination (ASTM C 295)

A petrographic examination is a procedure used to identify the physical and chemical properties of aggregates that have a bearing on the quality of the material in consideration of its intended use. Typical properties analyzed include: description and classification of constituents, relative amounts of constituents, particle coatings, rock type, particle condition

and particle shape, texture and structure, color, mineral composition and heterogeneities, and presence of constituents known to cause deleterious chemical reactions in concrete.

Alkali Reactivity

Alkali-Silica ASTM C 227

A potential alkali-silica reactivity test evaluates the susceptibility of cement-aggregate combinations to expansive reactions involving the alkalies sodium and potassium by measurement of the increase (or decrease) in length of mortar bars containing the combination during storage under prescribed conditions of test.

Alkali-Carbonate ASTM Proposed Standard

A potential alkali-carbonate reactivity test evaluates the susceptibility of cement-aggregate combinations to expansive reactions involving the carbonates of dolomite (in certain calcitic dolomites and dolomitic limestones) by measurement of the increase (or decrease) in length of concrete specimens (prisms) containing the combination during storage under prescribed conditions of test. This test is a proposed ASTM standard and has not been formally approved by the American Society of Testing and Materials.

AGGREGATE USE CLASSIFICATION

Road Base Aggregate

RBIa Basin-fill or rock sources containing materials suitable for use as road-base aggregates; based on acceptable laboratory aggregate test results.

RBIb Basin-fill sources containing materials suitable for use as road-base aggregates; based on correlation with Class RBIa areas.

RB II Potential basin-fill sources of materials suitable for use as road-base aggregates; based on photogeologic interpretations, field observations, and limited or inconclusive sieve analysis and/or abrasion data.

<u>Concrete Aggregate</u>	CA1	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths equal to or greater than 6500 psi.
	CA2	Basin-fill or rock sources containing aggregates that produced trial mix concrete with 28-day compressive strengths less than 6500 psi.
	CB	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on acceptable laboratory aggregate test results.
	CC1	Basin-fill or rock sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CA1 or CA2 source areas.
	CC2	Basin-fill sources containing aggregates potentially suitable for use in concrete; based on correlation with Class CB source areas.
	FA	Basin-fill sources containing fine aggregates used with crushed-rock samples for certain concrete trial mixes.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/ OR COBBLES	DISTRIBUTION OF MATERIAL FINER THAN COBBLES (PERCENT) GRAVEL	SAND	FINES
201	MS-A-1	Muleshoe Valley, SW	Aaf	Sandy Gravel	GP-GM	-/Few			
202	MS-A-2	Muleshoe Valley, SW	Aaf	Sandy Gravel	GM	-/Few			
	MS-A-(1,2)			Gravelly Sand	SM				
203	MS-A-3	Muleshoe Valley, SW	Aaf	Gravelly Sand	SM		30	50	20
204	MS-A-4	Muleshoe Valley, E	Aaf	Silty Sand	SM				
205	MS-A-5	Muleshoe Valley, E	Aaf	Gravelly Sand	SW-SM	-/Few			
206	MS-A-6	Muleshoe Valley, E	Aaf	Gravelly Sand	SW-SM	-/Few			
	MS-A-(4, 5, 6)			Gravelly Sand	SW-SM				
207	MS-A-7	Muleshoe Valley, NE	Aaf	Sandy Gravel	GP-GM	Rare/ Some			
208	MS-A-8	Muleshoe Valley, NE	Aaf	Sandy Gravel	GM	-/Few			
209	MS-A-9	Muleshoe Valley, NE	Aaf	Sandy Gravel	GM	Rare/ Few			
	MS-A-(7, 8, 9)			Sandy Gravel	GM				

FIELD OBSERVATIONS

... OF ...ER ...ES ... / FINES	OVERBURDEN THICKNESS (FEET)	TOTAL TRENCH DEPTH (FEET; R= REFUSAL DEPTH)	DELETERIOUS MATERIALS (MATERIAL/DEPTHS/ STAGE)	PLASTICITY	HARDNESS	WEATHERING	SIEVE ANAL... 3 IN.	2½ IN.	2 IN.	1½ IN.	1 IN.	¾ IN...
	1.0	12.5	Caliche/1-3/ III	Slight			100	98.3	97.3	95.3	91.8	85
	1.0	8.0(R)	Caliche/1-3/ III	Slight			100	97.9	97.0	94.4	86.4	79
							100	99.1	97.7	95.7	91.8	88
20	1.0	4.5(R)	Caliche/1-4.5/ III									
	1.0	13.0	Caliche/1-5/ III	Slight			100	97.6	96.3	93.8	88.2	83
	1.0	12.0	Caliche/1-5/ III	Slight						100	96.5	93
	1.0	12.0	Caliche/1-6/ III	Slight			92.1	92.1	92.1	92.1	88.8	88
							100	98.2	97.5	95.6	91.2	89
	1.0	12.5	Caliche/1-3, 8-9/ III,II	Slight			93.5	91.7	89.0	85.0	76.4	67
	1.0	13.0	Caliche/1-3/ III	Slight					100	96.9	89.4	83
	1.0	12.5	Caliche/1-4/ III	Slight			100	97.2	97.2	95.8	92.0	86
							98.2	96.4	95.2	93.6	87.1	80

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LABORATORY TEST DATA

...NALYSIS, ASTM C 136 (PERCENT PASSING)										SPECIFIC GRAVITY AND ABSORPTION, ASTM C 127 AND C 128							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY				SPECIFIC GRAVITY			
3/4 IN.	1/2 IN.	3/8 IN.	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	BULK	BULK SSD	APPAR-ENT	ABSORP. (PERCENT)	BULK	BULK SSD	APPAR-ENT	ABSORP. (PERCENT)
85.5	75.9	66.1	43.9	33.0	28.0	23.9	19.6	15.0	10.4								
79.6	70.5	62.5	46.9	36.9	31.3	28.0	24.9	20.9	16.1								
88.0	82.5	77.5	65.5	53.3	45.9	40.7	34.8	28.5	20.4								
83.8	78.8	75.9	68.0	59.2	46.2	36.1	29.2	24.5	19.5								
93.0	87.2	83.0	70.3	51.7	34.4	23.3	16.5	12.0	9.0								
88.2	83.3	79.8	72.5	59.5	42.6	27.6	17.6	13.2	9.7								
89.1	85.7	83.2	75.1	59.7	40.6	26.9	18.7	14.9	11.6								
67.3	56.0	47.4	33.9	27.0	22.2	19.1	16.5	14.2	9.6								
83.5	71.8	61.9	51.2	37.8	29.0	24.2	21.0	18.3	14.0								
86.8	78.6	70.8	52.1	39.5	32.5	27.6	22.7	18.7	13.1								
80.4	71.4	63.6	46.7	36.0	29.0	24.5	20.5	17.3	12.7								

3

TE ABSORP. (PERCENT)	FINENESS MODULUS (PERCENT)	UNIT WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS) COARSE AGGREGATE $MgSO_4$	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS) COARSE AGGREGATE $NaSO_4$	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS) FINE AGGREGATE $MgSO_4$	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS) FINE AGGREGATE $NaSO_4$	PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	ALKALI REACTIVITY CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)
			25.5							
			34.5							
			26.7	6.6						

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SUMMARY OF FIEL
TEST
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T WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS) COARSE AGGREGATE		FINE AGGREGATE		PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	AGGREGATE USE CLASSIFICATION
		$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
									RBIa,CB
									RBIa,CB
	25.5								
									RBIb,-
									RBIa,CB
									RBIa,CB
									RBIa,CB
	34.5								
									RBIa,CB
									RBIa,CB
									RBIa,CB
	26.7	6.6							

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SUMMARY OF FIELD AND LABORATORY TEST DATA
MULESHOE VALLEY, NEVADA

8 JUNE 81 TABLE A-1

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	MATERIAL DESCRIPTION	USCS SYMBOL	BOULDERS AND/OR COBBLES	DISTRIBUTION OF MATERIAL FINER THAN COBBLES (PERCENT)		
							GRAVEL	SAND	FINES
210	MS-FA-1	Muleshoe Valley, C	Aaf	Gravelly Sand	SM				
	MS-FA-1			No.4-No.200					
211	MS-R-1			Limestone					
	MS-R-1			1.5in-0.75in					
	MS-R-1			0.75in-No.4					
	MS-R-1			Blend(1.5in-No.4)					

FIELD OBSERVATIONS												
OVERBURDEN THICKNESS (FEET)	TOTAL TRENCH DEPTH (FEET; R= REFUSAL DEPTH)	DELETERIOUS MATERIALS (MATERIAL/DEPTHS/ STAGE)	PLASTICITY	HARDNESS	WEATHERING	SIEVE ANALYSIS						
						3 IN.	2½ IN.	2 IN.	1½ IN.	1 IN.	¾ IN.	
		Chert;Caliche/-/I				100	98.3	96.1	92.6	87.1	84.5	
				Hard	Slight							
									100	72.6	9.8	
											100	

2

LABORATORY TEST DATA

LYSIS, ASTM C 136 (PERCENT PASSING)										SPECIFIC GRAVITY AND ABSORPTION, ASTM C 127 AND C 128							
										COARSE AGGREGATE				FINE AGGREGATE			
										SPECIFIC GRAVITY				SPECIFIC GRAVITY			
¾ IN.	½ IN.	⅜ IN.	NO. 4	NO. 8	NO. 16	NO. 30	NO. 50	NO. 100	NO. 200	BULK	BULK SSD	APPARENT	ABSORP. (PERCENT)	BULK	BULK SSD	APPARENT	ABSORP. (PERCENT)
[illegible].5	80.1	77.1	70.3	64.3	53.8	40.5	27.9	20.2	15.0								
			100	89.2	71.0	46.8	22.0	7.4	2.6					2.47	2.57	2.74	4.0
[illegible]9.8	2.0													2.68	2.69	2.70	0.2
[illegible]0	60.0	35.8	1.2											2.68	2.69	2.71	0.5

3

FINENESS MODULUS (PERCENT)	UNIT WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
			COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
			$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
										-,FA
					41.4	17.1	Performed	In Progress		
			2.2				Performed			RBIa,CA
	89.0						Performed			
	96.2	33.3								

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SUMMARY OF FIELD AND
TEST DATA
MULESHOE VALLEY,

5 JUN 81 TABLE A-1

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UNIT WEIGHT (PCF)	ABRASION TEST ASTM C 131 (PERCENT WEAR)	SOUNDNESS TEST, ASTM C 88 (PERCENT LOSS)				PETROGRAPHIC EXAMINATION ASTM C 295	ALKALI REACTIVITY		AGGREGATE USE CLASSIFICATION
		COARSE AGGREGATE		FINE AGGREGATE			SILICA METHOD, ASTM C 227 (LENGTH CHANGE, PERCENT)	CARBONATE METHOD, PROP. ASTM (LENGTH CHANGE, PERCENT)	
		$MgSO_4$	$NaSO_4$	$MgSO_4$	$NaSO_4$				
									-,FA
				41.4	17.1	Performed	In Progress		
		2.2				Performed			RBIa,CA1
89.0						Performed			
96.2	33.3								

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SUMMARY OF FIELD AND LABORATORY TEST DATA
MULESHOE VALLEY, NEVADA

5 JUN 81 TABLE A-1 PAGE 2 OF 2

APPENDIX B

SUMMARY OF FIELD PETROGRAPHIC AND GRAIN-SIZE ANALYSES

FIELD PETROGRAPHIC AND GRAIN-SIZE ANALYSES

Field petrographic observations are presented in Table B-1. Field stations were established at various locations throughout the study area where detailed petrographic descriptions of potential basin-fill sources of aggregates were recorded. Detailed explanations for the column headings of Table B-1 are as follows:

COLUMN HEADING	EXPLANATION
MAP NUMBER	Map numbers are sequentially arranged identifiers of field petrographic stations occupied during the course of the aggregate study.
FIELD STATION	These designations are internal DARS identifiers of field petrographic designations.
LOCATION	The location column lists the geographic portion of the valley in which the field station is located (e.g., NE-northeast).
GEOLOGIC UNIT	The geologic unit listed is a term used to differentiate basin-fill deposits based on geomorphology. A geologic unit cross reference, outlining all units used, is included as Table F-3.
FIELD OBSERVATIONS	
Clast Count	Clast or petrographic counts are the main data collected during the field petrographic analysis. Data collected include lithology and percent present by size. Categorization by lithology is done to determine general percentages of nondeleterious and deleterious materials.
Other Deleterious Clasts Present	This column is reserved for recording additional types of materials present that are of poor quality for use as aggregate. Items mentioned include samples of rock types not sieved, counted, and described under clast count, such as: amorphous silica

(chert, opal, chalcedony), volcanic glass, mica, chlorite, friable materials, low density clasts (ash, vesicles, pumice, cinders), gypsum, pyrite, organic material, and coatings (clay and caliche).

Size Distribution	The estimated occurrence of boulders and cobbles is based on the appraisal of an entire deposit only if the materials are observed in the banks of prominent stream channels. Size distribution information for gravel was generally recorded only at trench locations. Any gravel values given are expressed as a percent of the total amount of less than 3.0-inch material present. The numeral zero is used to indicate a size fraction not observed, and the letter R is used to indicate the rare occurrence of a size fraction (one to four percent).
Gradation	Gradation information was recorded at trench locations only.
Maximum Particle Size	Maximum particle size is defined as the intermediate diameter length of the most frequently occurring clast present in a deposit (in centimeters). Erratic oversized materials (boulders, large cobbles) are generally not represented as the maximum particle size.
Particle Shape	Shape of clasts are classified into the following six categories.
Angular (ANG)	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Sub-angular (SA)	Particles are similar to angular but have somewhat rounded edges.
Sub-rounded (SR)	Particles exhibit nearly plane sides but have well-rounded corners and edges.
Rounded (R)	Particles have smoothly curved sides and no edges.
Platey (P)	Particles are thin and flat with either rounded or nonrounded corners and edges.
Elongate (E)	Particles are several times longer than they are wide with rounded corners and edges.

Remarks

This column is used to describe the general site location of petrographic field stations; location terms used include: surface, shallow wash, stream channel bank or bottom, borrow pit, and road cut. Surface indicates analysis was performed on top of the stated geologic unit. Shallow wash indicates analysis was performed on top of the unit but at the bottom of a small swale. Stream channel bank or bottom indicates analysis was performed in an exposed section (incision) or within a minor stream channel deposit, respectively.

MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	CLAST COUNT, > 1 IN. TO ≤ 3 IN. DIAMETER							
				NON-DELETERIOUS						DEL	
				Qtz	Ls	Do	Gr	Vu	Vb	CALI-CHE	CHERT
301	MS-1	Muleshoe Valley, SW	Aaf	12	18	70					
302	MS-2	Muleshoe Valley, SW	Aaf	78	10	4				8	
303	MS-3	Muleshoe Valley, SW	Aaf	34	42	14		4		6	
304	MS-4	Muleshoe Valley S	Aaf	6	52	40				2	
305	MS-5	Muleshoe Valley C	Aaf	10	76	4		6		4	
306	MS-7	Muleshoe Valley, SW	Aaf	2	8	84		2		2	2
307	MS-8	Muleshoe Valley, E	Aaf		78	8				12	2
308	MS-9	Muleshoe Valley, NE	Aaf		76	4				20	
309	MS-10	Muleshoe Valley, NE	Aaf		44	10		44			
310	MS-11	Muleshoe Valley, NE	Aaf		86	4				10	
311	MS-12	Muleshoe Valley, N	Aaf	54	32	8				6	
312	MS-13	Muleshoe Valley, C	Aaf		84	6				10	
313	MS-14	Muleshoe Valley, C	Aaf	6	72	6				16	

FIELD OBSERVATIONS

...TER (PERCENT)				CLAST COUNT, > ½ IN. TO ≤ 1 IN. DIAMETER (PERCENT)											OTHER DELETERIOUS CLASTS PRESENT
DELETERIOUS				NON-DELETERIOUS						DELETERIOUS					
...HERT	TUFF	GLASS	OTHER	Qtz	Ls	Do	Gr	Vu	Vb	CALICHE	CHERT	TUFF	GLASS	OTHER	
				24	30	40				6					Caliche
				52	38				2	8					Caliche
				22	52	8				18					Caliche
				10	56	34									Caliche
				8	78					10				4	Caliche
2				6	10	82				2					Caliche
2					84					12	4				Caliche
					64					28	8				Caliche
	2				40			58			2				Caliche
					70	4			4	22					Caliche
				52	32					16					Caliche
					86	2				12					Caliche
				2	80	10				8					Caliche

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OTHER DELETERIOUS CLASTS PRESENT	SIZE DISTRIBUTION			GRADATION	MAXIMUM PARTICLE SIZE (CM)	PARTICLE SHAPE	REMARKS
	PERCENT OF TOTAL		<3" %				
	BOUL-DERS	COB-BLES	GRA-VEL				
Caliche					5	SA,SR	Stream Channel
Caliche					7	A,SA,SR	Shallow Wash
Caliche					6	SA,SR	Shallow Wash
Caliche					8	A,SA,SR	Surface
Caliche	0	5		Poor	6	SA,SR	Borrow Pitt
Caliche					5	SA,SR	Road Cut
Caliche					8	A,SA,SR	Surface
Caliche					9	A,SA,SR	Surface
Caliche					5	A,SA	Stream Channel
Caliche					8	A,SA	Surface
Caliche					10	A,SA	Shallow Wash
Caliche					5	A,SA	Shallow Wash
Caliche					10	A,SA	Stream Channel,Bank

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SUMMARY OF FIELD PETROGRAPHIC
AND GRAIN-SIZE ANALYSES
MULESHOE VALLEY, NEVADA

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MAP NUMBER	FIELD STATION	LOCATION	GEOLOGIC UNIT	CLAST COUNT, > 1 IN. TO ≤ 3 IN. DIAMETER							
				NON-DELETERIOUS						DELE	
				Qtz	Ls	Do	Gr	Vu	Vb	CALI-CHE	CHERT
314	MS-15	Muleshoe Valley, C	Aaf	8	90						2
315	MS-16	Muleshoe Valley, S	Aaf		94	2				4	

FIELD OBSERVATIONS

R (PERCENT)				CLAST COUNT, > ½ IN. TO ≤ 1 IN. DIAMETER (PERCENT)											OTHER DELETERIOUS CLASTS PRESENT	SI
ELETERIOUS				NON-DELETERIOUS						DELETERIOUS						PE
RT	TUFF	GLASS	OTHER	Qtz	Ls	Do	Gr	Vu	Vb	CALICHE	CHERT	TUFF	GLASS	OTHER		BO DI
				4	76					4	16				Caliche,Chert	
					54	2				44					Caliche	

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UNCLASSIFIED E-TR-47-MS NL

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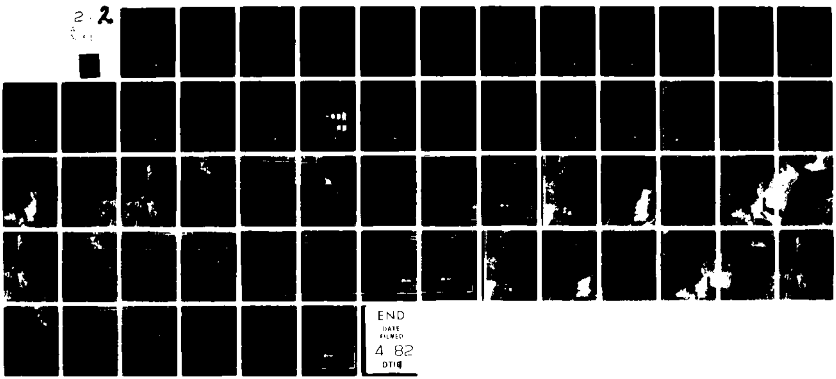

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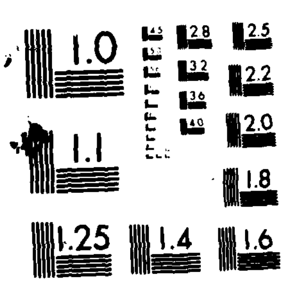

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OTHER [D]ELETERIOUS [CL]ASTS PRESENT	SIZE DISTRIBUTION PERCENT OF TOTAL BOUL-DERS	COB-BLES	<3" % GRA-VEL	GRADATION	MAXIMUM PARTICLE SIZE (CM)	PARTICLE SHAPE	REMARKS
[C]aliche,Chert					12	A,SA	Shallow Wash
[C]aliche					9	A,SA	Road Cut

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SUMMARY OF FIELD PETROGRAPHIC
AND GRAIN-SIZE ANALYSES
MULESHOE VALLEY, NEVADA

5 JUN 81 TABLE B-1 PAGE 2 OF 2

APPENDIX C

TRENCH LOGS

EXPLANATION OF TRENCH LOGS

Trench logs were completed for excavated trenches. Each log presented in this appendix is chosen from a group of trench logs so that it represents the general aggregate conditions and properties of that entire group. Occasionally, the full compliment of trenches in a group was not excavated due to low gravel percentages and/or advanced caliche development found in the first one or two trenches of that group. Detailed explanations of the trench logs headings are as follows:

COLUMN HEADING		EXPLANATION
BULK SAMPLE		Representative samples were obtained by channel sampling a trench wall. Overburden and, in some trenches, dense caliche layers were avoided during the sampling procedure.
	II -	100 lb. sample (2 bags) for road-base aggregate testing.
	III -	400 lb. sample (55 gallon barrel) for concrete aggregate testing.
DEPTH		Depth corresponds to depth below ground surface in meters and feet.
LITHOLOGY		Graphic representation of soil types present in excavation.
USCS		Unified Soil Classification System symbols. For detailed informat see Table F-1.
CONSISTENCY		The consistency of the in-situ deposit was estimated by visual observation of the soil in the trench walls, ease (or difficulty) of excavation of the trench, and trench-wall stability. Consistency descriptions of coarse-grained soils (GW, GP, GM, GC, SW, SP, SM, SC) are as follows:

	DESCRIPTION
Very Loose (VL)	Will not hold vertical cut (when dry).

Loose (L)	Will hold vertical cut, but caves if disturbed.
Medium Dense (MD)	Holds vertical cut, even when disturbed; easily excavated.
Dense (D)	Holds vertical cut, difficult to excavate.
Very Dense (VD)	Very difficult to impossible to excavate.

SOIL DESCRIPTION

Except in cases where samples were classified based on laboratory data, the descriptions are based on visual classification. The procedures outlined in ASTM D 2487-69, Classification of Soils for Engineering Purposes and D 2488-69, Description of Soils (Visual-Manual Procedure) were followed. Solid lines across the column indicate known changes in the strata at the depth shown.

Definitions of some of the terms and criteria used to describe soils and conditions encountered during the excavation follow:

Descriptive Name — Name of soil, as determined by USCS, preceded by an adjective indicating the size range of the most abundant secondary material present.

Particle Size — For coarse-grained soils (sands and gravels) the size range of the particles visible to the unaided eye was estimated as fine, medium, coarse, or a combined range (e.g., fine to medium). These terms approximately correspond to the following sieve sizes:

Gravel	Fine	No. 4 to 3/4-inch sieve
	Coarse	3/4-inch to 3-inch sieve
Sand	Fine	No. 200 to No. 40 sieve
	Medium	No. 40 to No. 10 sieve
	Coarse	No. 10 to No. 4 sieve

Particle Shape — See Appendix B explanation pages.

Gradation — Gradations listed are those determined from percent amounts of boulders, cobbles, and gravel present. Descriptive terms used include: poor and well.

Poor(ly)	Predominantly one size or a range of sizes, with some intermediate sizes missing.
Well	Wide range in grain sizes present, with substantial amounts of most intermediate sizes.
Secondary Material	Percentage present by dry weight. Trace 5-12 percent Little 13-20 percent Some > 20 percent (e.g., Some slightly plastic silt)
Plasticity of Fines	See Appendix A explanation pages
HCL Reaction	As an aid for identifying calcium carbonate coatings and cementation, soil samples were tested in the field for their reaction to dilute hydrochloric acid. The intensity of the HCL reaction was described as none, weak, or strong.
Caliche	Caliche is a term applied to calcareous material of secondary accumulation. In this study, the definition includes both the soluble calcium (and other) salts and the clastic material (gravel, sand, silt or clay) in which the salts exist. See Table F-2 for a description of the stages of caliche development.
Cobbles and Boulders	See Appendix A explanation pages.
Lithology	The various rock types found in an excavated deposit are listed in order of decreasing abundance.
Remarks	This column was provided for comments regarding difficulty of excavation, caliche development, and backhoe refusal. Refusal indicates the inability of a JCB 3DIII backhoe (Case 680 equivalent) with a 2-foot wide bucket to excavate a trench to completion.
SIEVE ANALYSIS	The numbers cited represent the percentage by dry weight of each of the following soil components.

GR	Coarse aggregate particles that pass a 3-inch (75 mm) sieve but are predominantly retained on a No. 4 (4.75 mm) sieve.
SA	Fine aggregate particles that almost entirely pass a No. 4 sieve but are predominantly retained on a No. 200 (0.075 mm) sieve.
FI	Soil particles that pass a No. 200 sieve (silt and clay).

All percentages shown on logs are the result of laboratory testing.

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI
	0	0		SM	loose	GRAVELLY SAND, silty - OVERBURDEN				
		2		SM	very dense	GRAVELLY SAND, stage III caliche throughout - OVERBURDEN	difficult excavatability			
	1, 2	4, 6		GM	medium dense / very dense	SANDY GRAVEL, fine to coarse, subrounded, poorly graded; some fine to medium, subrounded sand; little silt; strong HCl reaction; some stage II caliche; few cobbles; limestone/dolomite, quartzite, minor volcanics.	Refusal	53	31	16
		8				TOTAL DEPTH 8.0 ft. (2.4m)				
	3, 4, 5, 6	10, 12, 14, 16, 18, 20								

TRENCH DETAILS

SURFACE ELEVATION : 5585 ft. (1702m)

DATE EXCAVATED : 4 November 1980

SURFACE GEOLOGIC UNIT : Aafg

TRENCH LENGTH : 15 ft. (4.6m)

TRENCH ORIENTATION : N - S

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TRENCH LOG OF MS-A-2
MULESHOE VALLEY, NEVADA

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FIGURE C-1

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI
	0	0		SM	loose	SILTY SAND - OVERBURDEN				
	1	2, 4		SM	very dense	GRAVELLY SAND, fine to medium, subrounded, poorly graded; some fine to coarse, subrounded gravel; some slightly plastic silt; strong HCl reaction; stage III caliche throughout.	Refusal			
						TOTAL DEPTH 4 ft. (1.2m)				
	2, 3, 4, 5, 6	6, 8, 10, 12, 14, 16, 18, 20								

TRENCH DETAILS

SURFACE ELEVATION : 5635 ft. (1717m)

DATE EXCAVATED : 4 November 1980

SURFACE GEOLOGIC UNIT : Aafg

TRENCH LENGTH : 11 ft. (3.3m)

TRENCH ORIENTATION : E - W

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TRENCH LOG OF MS-A-3
MULESHOE VALLEY, NEVADA

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FIGURE C-8

BULK SAMPLE	DEPTH METERS	DEPTH FEET	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI
	0	0		SM	loose	SILTY SAND - OVERBURDEN				
	1	2, 4		SM	very dense	GRAVELLY SAND, fine to medium, subrounded, poorly graded; some fine to coarse, subrounded gravel; some silt; strong HCl reaction; stage III caliche throughout.				
	2, 3	6, 8, 10		SW-SM	medium dense	GRAVELLY SAND, fine to medium, subrounded, well graded; some fine to coarse, subrounded gravel; trace slightly plastic silt; strong HCl reaction; some stage I - II caliche; few cobbles; gravel is limestone/dolomite, volcanics, and quartzite, sand is predominantly volcanics.		30	61	9
	4, 5, 6	12, 14, 16, 18, 20				TOTAL DEPTH 12 ft. (3.7m)				

TRENCH DETAILS

SURFACE ELEVATION : 6005 ft. (1830m)
DATE EXCAVATED : 4 November 1980
SURFACE GEOLOGIC UNIT : Asfs
TRENCH LENGTH : 15 ft. (4.6m)
TRENCH ORIENTATION : N - S

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TRENCH LOG OF MS-A-5
MULESHOE VALLEY, NEVADA

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FIGURE C-5

BULK SAMPLE	DEPTH (METERS / FEET)	LITHOLOGY	USCS	CONSISTENCY	SOIL DESCRIPTION	REMARKS	SIEVE ANALYSIS GR	SA	FI
	0 / 0		SM	loose	SILTY SAND - OVERBURDEN				
	2 ft		GM	dense	SANDY GRAVEL, silty, stage III caliche throughout.				
	1 m; 4, 6 ft; 2 m; 8, 10 ft; 3 m; 12 ft		GP-GM	medium dense	SANDY GRAVEL, fine to coarse, subrounded, poorly graded; some fine to medium, subrounded sand; trace silt; strong HCl reaction; some stage I - II caliche; few cobbles; rare boulder; limestone/dolomite, quartzite.		64	26	10
	4 m; 14, 16 ft; 5 m; 18, 20 ft; 6 m				TOTAL DEPTH 12.5 ft. (3.8m)				

TRENCH DETAILS

SURFACE ELEVATION : 6190 ft. (1887m)
DATE EXCAVATED : 5 November 1980
SURFACE GEOLOGIC UNIT : Aafg
TRENCH LENGTH : 15 ft. (4.6m)
TRENCH ORIENTATION : N - S

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TRENCH LOG OF MS-A-7
MULESHOE VALLEY, NEVADA

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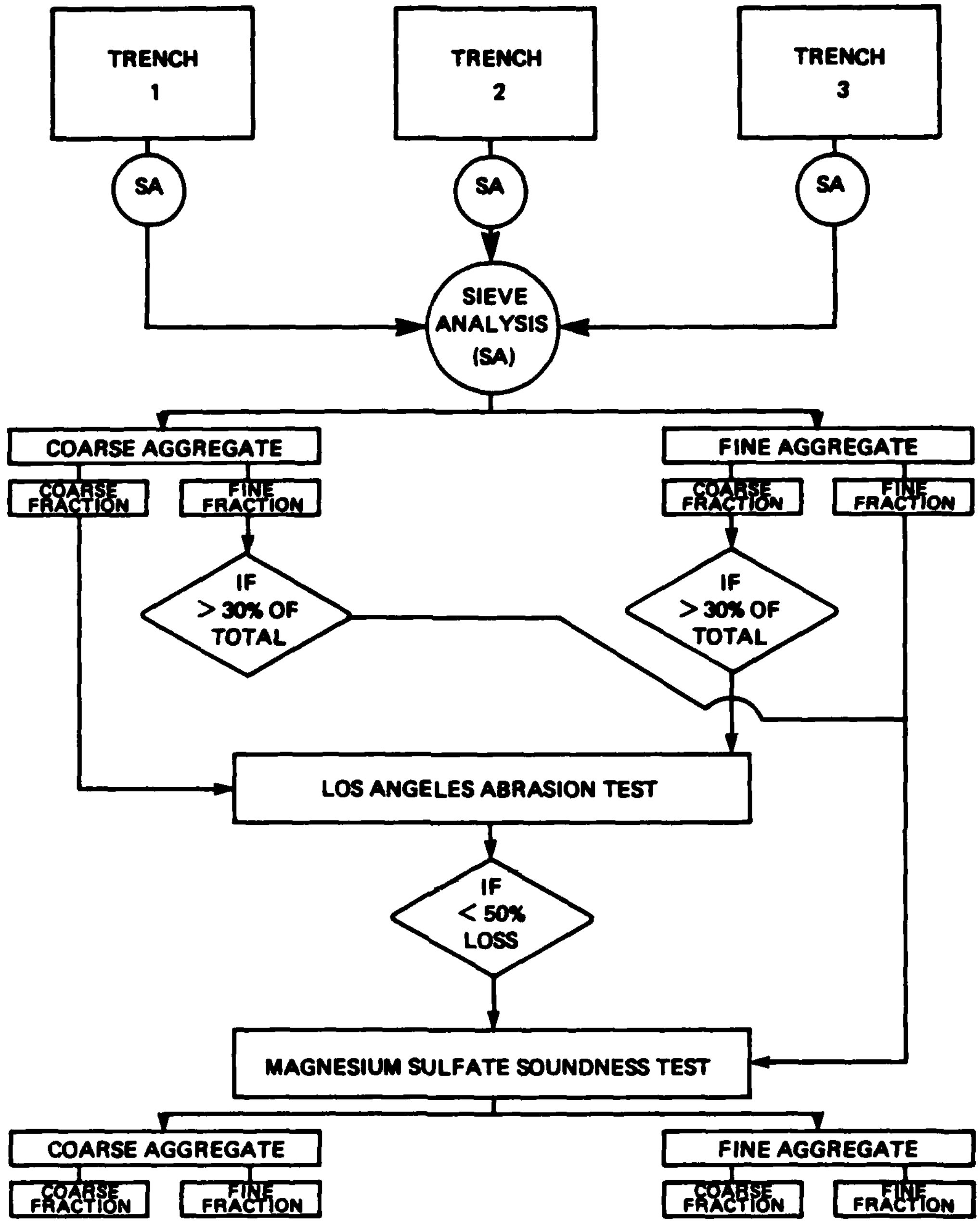
FIGURE C-4

APPENDIX D

FLOW DIAGRAM - ROAD-BASE AGGREGATES TESTING

FLOW DIAGRAM - CONCRETE TRIAL MIX DESIGN AND TESTING



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FLOW DIAGRAM — ROAD BASE AGGREGATES TESTING

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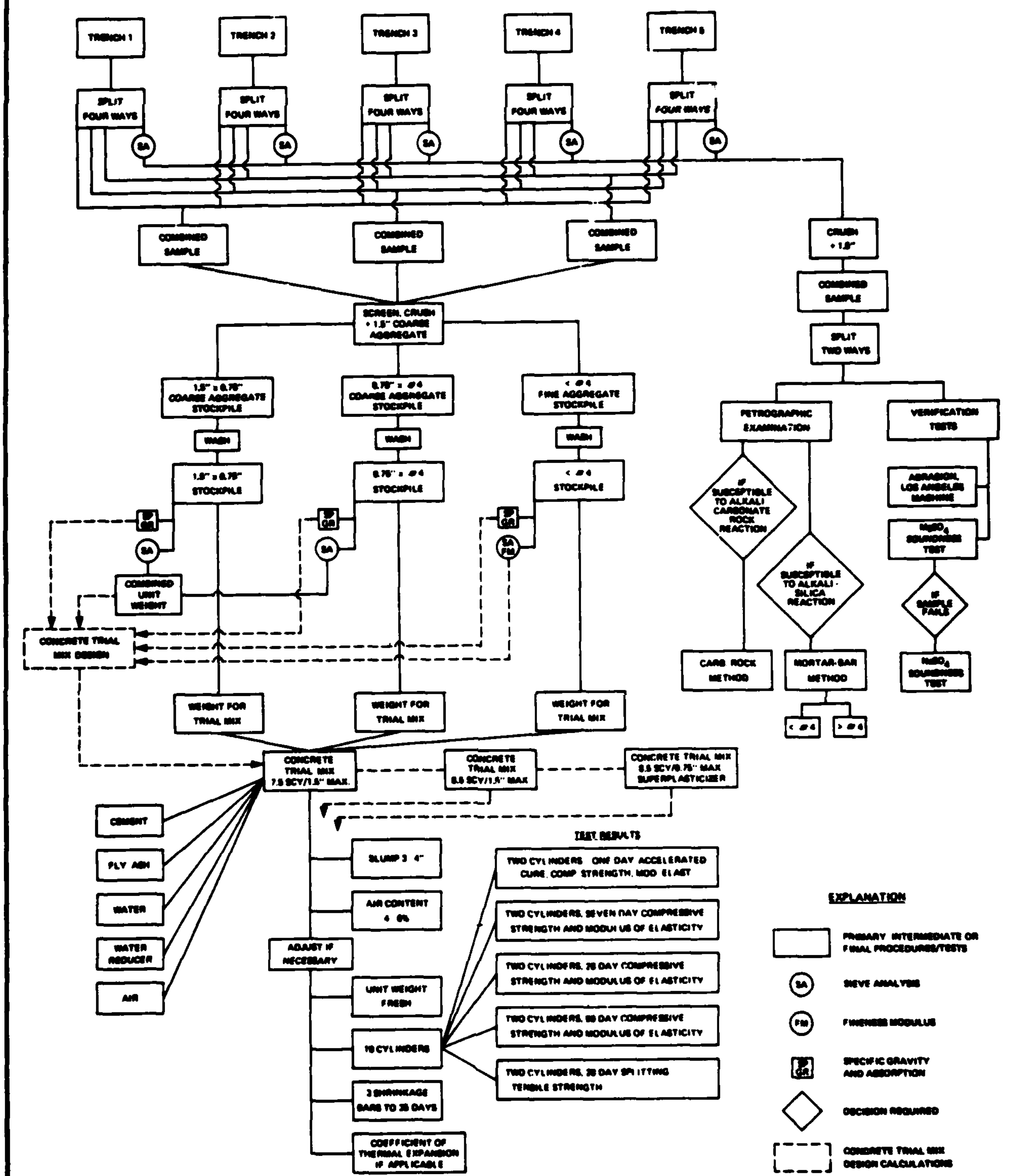
FIGURE D-1



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FLOW DIAGRAM – CONCRETE TRIAL MIX DESIGN AND TESTING

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FIGURE D-2

APPENDIX E

CHEMICAL ANALYSES OF CEMENT,
FLY ASH, AND WATER USED IN
CONCRETE TRIAL MIXES

	PROPERTY ANALYZED	TOTAL PERCENTAGE OF SAMPLE	MINIMUM OR MAXIMUM REQUIREMENTS
CEMENT ASTM C 150, TYPE II	SiO_2	26.8	20.0 MIN.
	AL_2O_3	1.96	6.0 MAX.
	Fe_2O_3	2.71	6.0 MAX.
	MgO	1.57	6.0 MAX.
	ALKALIES (Na_2O + 0.658 K_2O)	0.53	0.60 MAX.
	LOSS ON IGNITION	0.56	3.0 MAX.
	SO_3	1.97	3.0 MAX.
	INSOLUBLE RESIDUE	0.61	0.75 MAX.
FLY ASH ASTM C 618, CLASS F	SiO_2	67.7	–
	AL_2O_2	17.2	–
	Fe_2O_3	8.34	–
	TOTAL	93.24	70.0 MIN.
	MgO	1.69	5.0 MAX.
	SO_3	0.14	5.0 MAX.
	Na_2O (OPTIONAL)	1.68	1.5 MAX.
	MOISTURE	0.08	3.0 MAX.
	LOSS ON IGNITION	0.63	12.0 MAX.
WATER CALIF. DEPT. TRANS. SEC. 90 - 2.03	pH	7.5	–
	COLOR	0 - 5	–
	SO_4	8 ppm	1300 ppm
	Cl	10.6 ppm	650 ppm
	OIL AND GREASE	NONE	NONE

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CHEMICAL ANALYSES OF CEMENT, FLY ASH, AND WATER USED IN CONCRETE TRIAL MIXES

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TABLE E-1

APPENDIX F

UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY OF CALICHE DEVELOPMENT

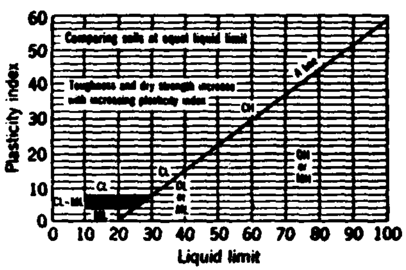
ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

Major Divisions			Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)	Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria
Coarse-grained soils: More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the ¼ in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics	Not meeting all gradation requirements for *GW*
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures	Example: *Silty sand, gravelly;* about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% nonplastic fines with low dry strength; well compacted and moist in place; *alluvial sand;* (*SM*)	Atterberg limits below "A" line, or *PI* less than 4 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures		Atterberg limits above "A" line, with *PI* greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for *SW*
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures		Atterberg limits below "A" line or *PI* less than 5 — Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures		Atterberg limits below "A" line with *PI* greater than 7

Laboratory classification criteria (coarse-grained soils): Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols.

Use grain size curve in identifying the fractions as given under field identification.

Major Divisions		Identification Procedures on Fraction Smaller than No. 40 Sieve Size: Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols[a]	Typical Names	Information Required for Describing Soils
Fine-grained soils: More than half of material is *smaller* than No. 200 sieve size (The No. 200 sieve size is about the smallest particle visible to naked eye)	Silts and clays, liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	Example: *Clayey silt,* brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
	Silts and clays, liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart for laboratory classification of fine grained soils

From Wagner, 1957.

[a] *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW–GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the *CH* group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

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UNIFIED SOIL CLASSIFICATION SYSTEM

8 JUN 81

TABLE F-1

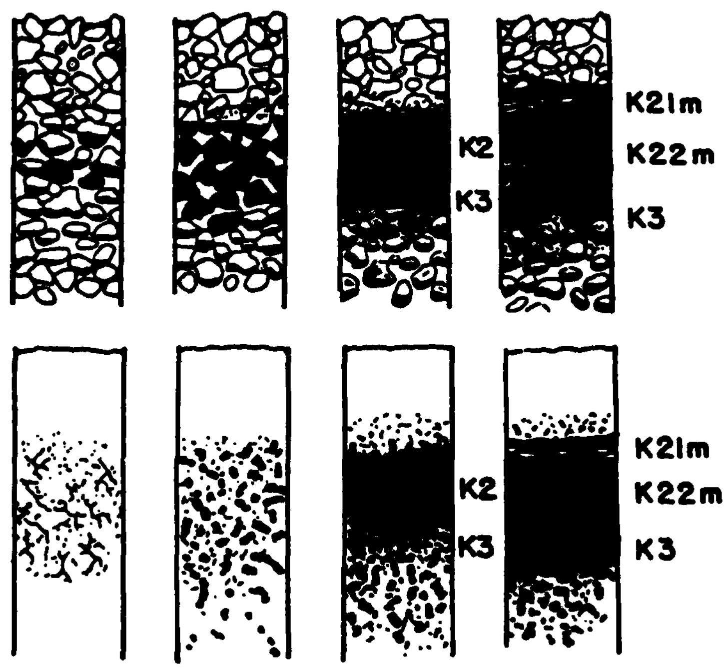
DIAGNOSTIC CARBONATE MORPHOLOGY

STAGE	GRAVELLY SOILS	NONGRAVELLY SOILS
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Laminar horizon overlying plugged horizon

STAGE	I Weak Ca	II Strong Ca	III K	IV Indurated K

GRAVELLY SOILS

NONGRAVELLY SOILS



Stages of development of a caliche profile with time. Stage I represents incipient carbonate accumulation, followed by continuous build-up of carbonate until, in Stage IV, the soil is completely plugged.

Reference: Gile, L.G. Peterson, F.F., and Grossman, R.B., 1965, The K horizon: A master horizon of carbonate accumulation: Soil Science, v. 99, p. 74-82.

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SUMMARY OF CALICHE DEVELOPMENT

8 JUN 81

TABLE F-2

UARSA POTENTIAL AGGREGATE SOURCE SYMBOLS	ERTEC WESTERN GENERAL GEOLOGIC UNIT EXPLANATION
	ROCK
	Shown in regions where rock is exposed; the areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur the predominant rock type is shown followed by the subordinate rock type (e.g. S_{2p}/I_1). Rock may be subdivided into bedrock (B).
	$\boxed{I}$ IGNEOUS (UNDIFFERENTIATED) Rocks formed by solidification of a molten or partially molten mass
GR	$\boxed{I_1}$ Intrusive. Plutonic rocks formed by solidification of molten material beneath the surface (e.g. granite, granodiorite, diorite, gabbro)
Vu	$\boxed{I_2}$ Extrusive (intermediate and acidic). Volcanic rocks of intermediate and acidic composition formed by solidification of molten material at or near the surface (e.g. rhyolite, latite, dacite, andesite)
Vb	$\boxed{I_3}$ Extrusive (basic). Volcanic rocks of basic composition generally formed by solidification of molten materials at or near the surface (e.g. basalt)
Vu	$\boxed{I_4}$ Extrusive (pyroclastic). Rocks formed by accumulation of volcanic ejecta (e.g. ash, tuff, welded tuff, agglomerate)
Su	$\boxed{S}$ SEDIMENTARY (UNDIFFERENTIATED) Rocks formed by accumulation of clastic solids, organic solids and/or chemically precipitated minerals
Su, Qtz	$\boxed{S_1}$ Arenaceous and/or Siliceous Rocks. Composed of sand size particles (e.g. sandstone, orthoquartzite) or of cryptocrystalline silica (e.g. opal, chert)
Ls, Do, Cau	$\boxed{S_2}$ Carbonate Rocks. Composed predominantly of calcium carbonate detritus or chemical precipitates (e.g. limestone, dolomite, chalk)
	$\boxed{S_3}$ Argillaceous Rocks. Composed of clay and silt-sized particles (e.g. siltstone, shale, claystone)
	$\boxed{S_4}$ Evaporite Rocks. Precipitated from solution as a result of evaporation (e.g. halite, gypsum, anhydrite, sylvite)
Su	$\boxed{S_5}$ Coarse Clastic Rocks. Composed of gravel-sized or larger clasts (e.g. conglomerate, breccia)
Mu	$\boxed{M}$ METAMORPHIC (UNDIFFERENTIATED) Rocks formed through recrystallization in the solid state of preexisting rocks by heat and pressure
Mu	$\boxed{M_1}$ Coarse grained rocks formed by higher-grade regional metamorphism, either banded or granular (e.g. gneiss, granulite, amphibolite)
Mu	$\boxed{M_2}$ Fine grained schistose rocks formed by lower grade regional metamorphism (e.g. schist, slate, phyllite)
Mu	$\boxed{M_3}$ Nonfoliated rocks formed chiefly by contact metamorphism (e.g. hornfels, marble)
Qtz	$\boxed{M_4}$ Metaquartzite rocks formed by metamorphism of highly siliceous rocks
	BASIN-FILL
	$\boxed{A}$ BASIN-FILL DEPOSITS Fine- to coarse-grained materials deposited principally by wind, water or gravity
Aal	$\boxed{A_1}$ Younger Fluvial Deposits. Major modern stream channel and flood-plain deposits
Au, Aal	$\boxed{A_2}$ Older Fluvial Deposits. Older incised stream channel and flood-plain deposits in elevated terraces bordering major modern drainages
Au	$\boxed{A_3}$ Eolian Deposits. Wind-blown deposits of sand occurring as either thin sheets (A_{3s}) or dunes (A_{3d})
Aol	$\boxed{A_4}$ Playa and Lacustrine Deposits. Deposits occurring in modern active playas (A_{4a}) or in either inactive playas or older lake beds and abandoned shorelines associated with extinct lakes (A_{4e})
Aaf	$\boxed{A_5}$ Alluvial Fan Deposits. Alluvial deposits consisting of debris flow and water-laid alluvium near mountain fronts, grading into predominantly water-laid alluvium deposited in shifting distributary channels near the basin center. Younger (A_{5y}), intermediate (A_{5i}) and older (A_{5o}) alluvial fans are differentiated by surface soil development, terrain conditions and present depositional erosional environment
Au	$\boxed{A_3/A_5}$ Mixed non-rock units. Most areally extensive unit is listed first
Aaf	$\boxed{A_{5y}\ (A_{5i})}$ Parenthetic unit underlies thin veneer of overlying, younger unit

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ERTEC WESTERN GEOLOGIC UNIT CROSS REFERENCE

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FIGURE F-3

APPENDIX G

CROSS REFERENCE FROM MAP
NUMBER TO VERIFICATION ACTIVITY

CROSS REFERENCE FROM MAP NUMBER TO VERIFICATION ACTIVITY

Included in this appendix is one table that is presented to allow cross reference to be made from this aggregate resources study to an appropriate verification study. Map numbers in the number series 400 to 599 on Drawing 1 are keyed to the in progress Verification report of Muleshoe Valley, Nevada (E-TR-27-MS-I and II). If detailed information is required from a verification activity, the following search procedure can be used: determine the location of the activity required on Drawing 1, note the map number, refer to that map number in Table G-1, read from that table the verification activity type and number, refer to the appropriate verification report for the data required.

MAP NUMBER	ACTIVITY LOCATION	MAP NUMBER	ACTIVITY LOCATION
401	GS - 16	423	GS - 29
402	P - 1	424	GS - 43
403	T - 1	425	GS - 26
404	GS - 18	426	GS - 27
405	P - 2	427	GS - 28
406	GS - 15	428	GS - 21
407	GS - 3	429	T - 4
408	GS - 22	430	CS - 8
409	T - 2	431	GS - 12
410	GS - 5	432	P - 4
411	GS - 19	433	CS - 10
412	T - 3	434	GS - 45
413	CS - 5	435	GS - 10
414	GS - 20	436	CS - 18
415	P - 3	437	T - 8
416	GS - 25	438	P - 7
417	GS - 13	439	GS - 9
418	GS - 14	440	GS - 47
419	GS - 4	441	GS - 11
420	GS - 44	442	GS - 46
421	GS - 24	443	GS - 8
422	GS - 23	444	GS - 7

T - TRENCH
B - BORING
P - TEST PIT
CS - SURFACE SAMPLE
GS - GEOLOGIC STATION

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CROSS REFERENCE FROM MAP NUMBER
TO VERIFICATION ACTIVITY
MULESHOE VALLEY, NEVADA

5 JUN 81 TABLE G-1 1 OF 2

MAP NUMBER	ACTIVITY LOCATION	MAP NUMBER	ACTIVITY LOCATION
445	P - 6	467	GS - 31
446	CS - 20	468	GS - 42
447	T - 5	469	GS - 48
448	CS - 13	470	P - 9
449	GS - 37		
450	GS - 36		
451	P - 5		
452	T - 7		
453	CS - 12		
454	T - 6		
455	GS - 41		
456	GS - 40		
457	GS - 38		
458	GS - 39		
459	CS - 23		
460	P - 8		
461	GS - 33		
462	GS - 34		
463	GS - 35		
464	GS - 32		
465	GS - 6		
466	GS - 30		

T - TRENCH
B - BORING
P - TEST PIT
CS - SURFACE SAMPLE
GS - GEOLOGIC STATION

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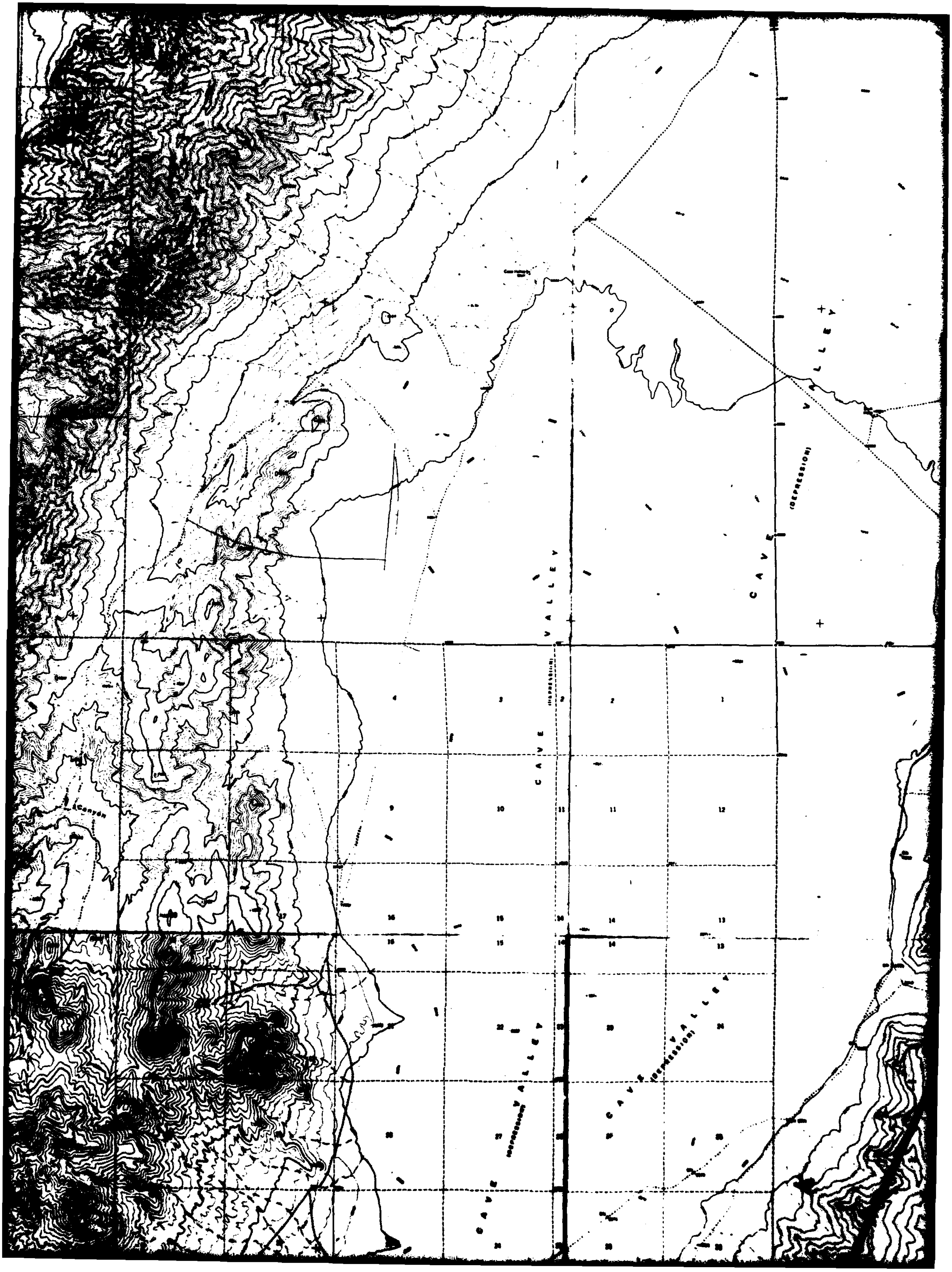
CROSS REFERENCE FROM MAP NUMBER
TO VERIFICATION ACTIVITY
MULESHOE VALLEY, NEVADA


CAVE VALLEY
(DEPRESSION)
CAVE VALLEY
CAVE VALLEY
CAVE VALLEY
(DEPRESSION)
CAVE VALLEY
(DEPRESSION)
Canyon
4
3
2
2
1
9
10
11
11
12
16
15
14
14
13
16
15
14
14
13
22
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24
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26
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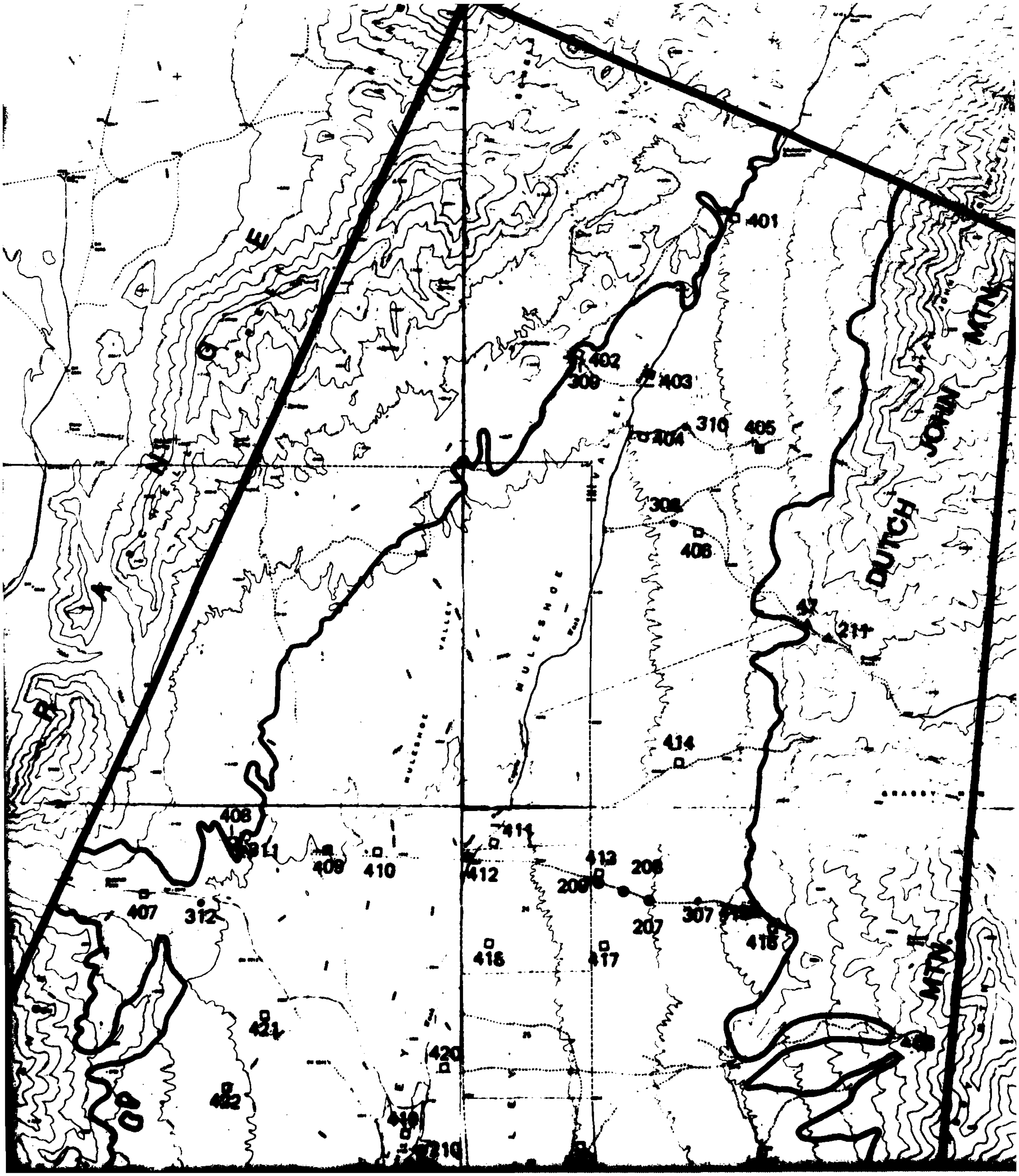
34



401
402
309
403
310
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404
308
406
DUTCH
JOHN
MTN.
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211
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MTN.
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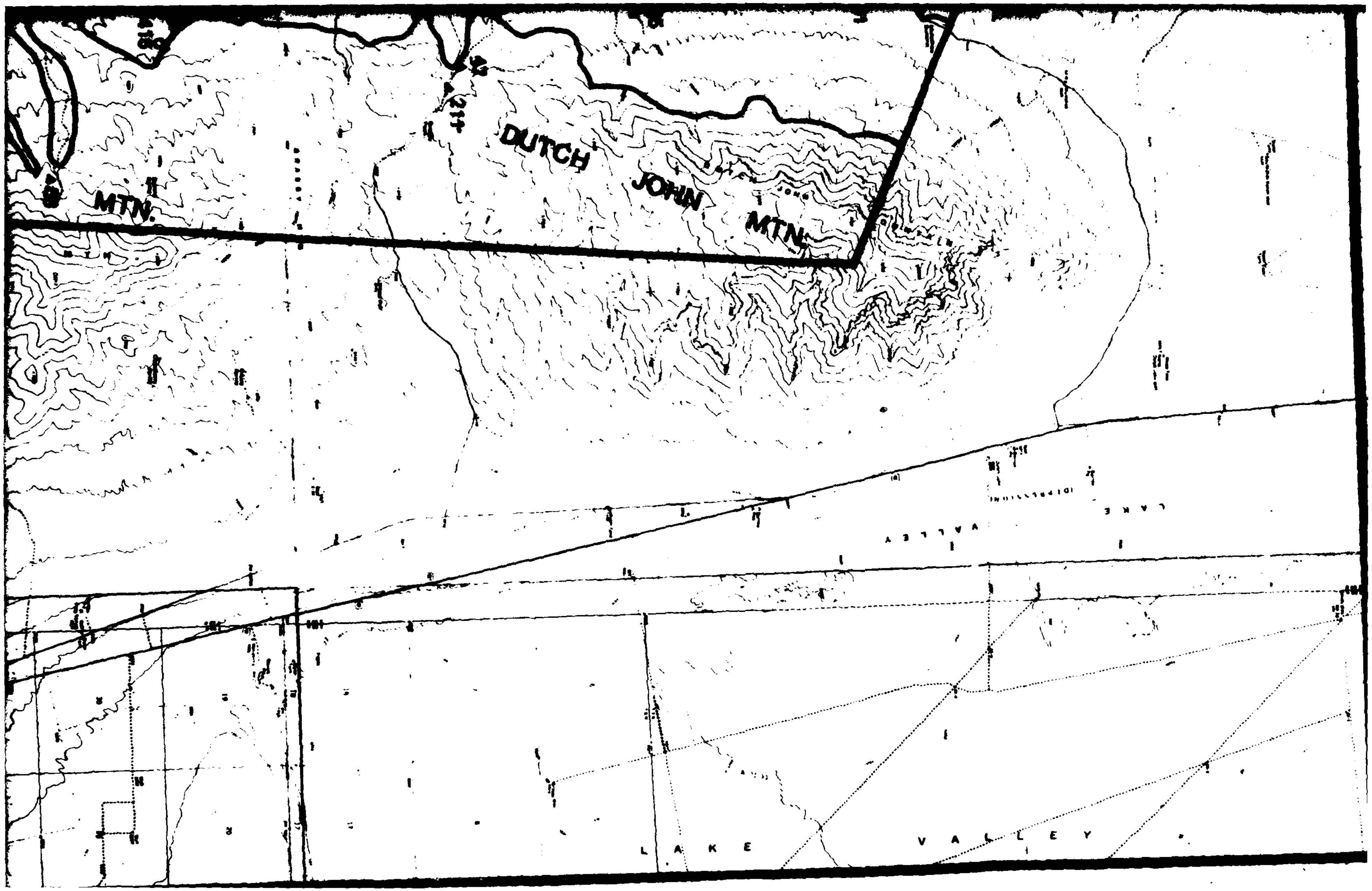
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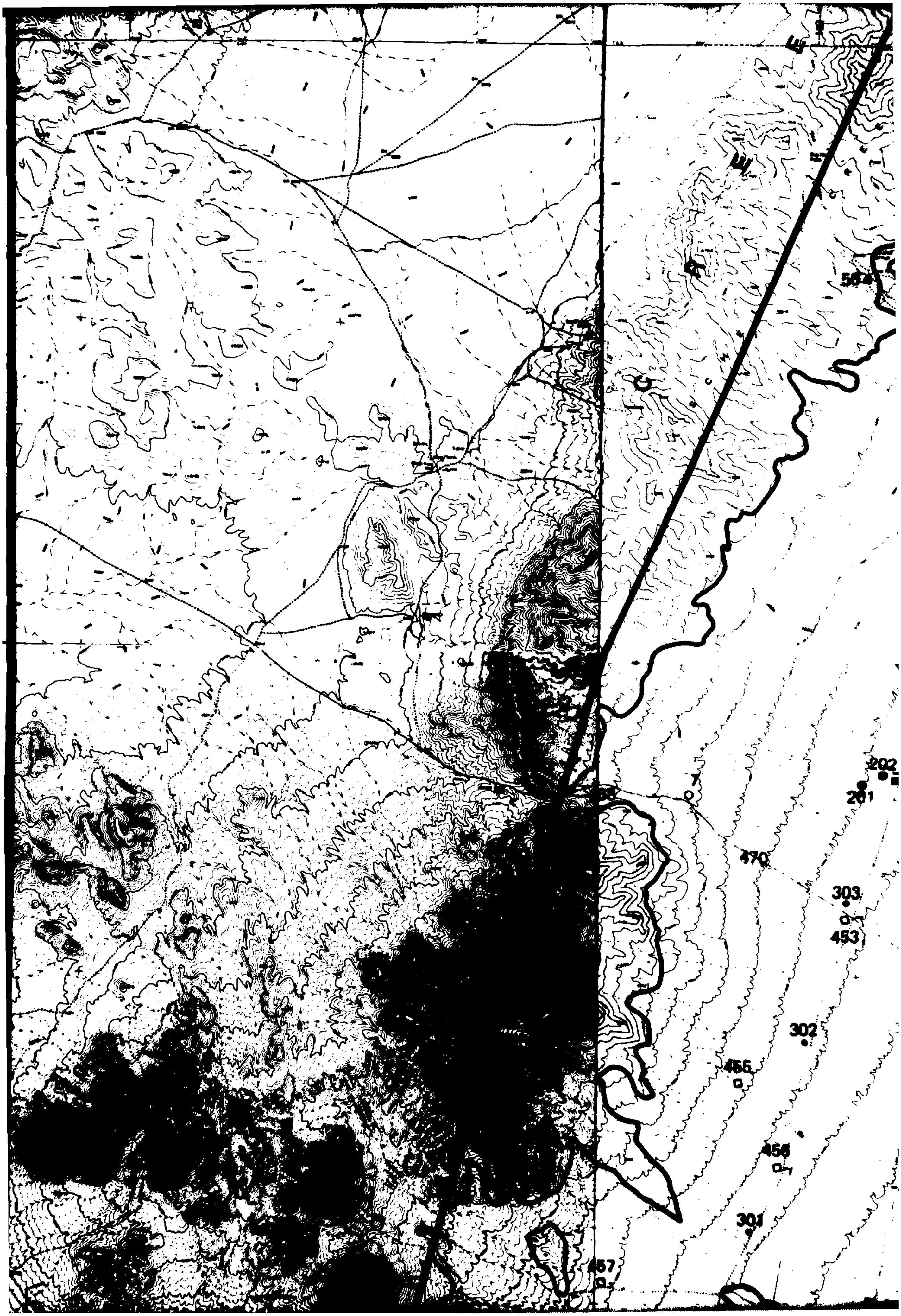
LAKE VALLEY
LAKE VALLEY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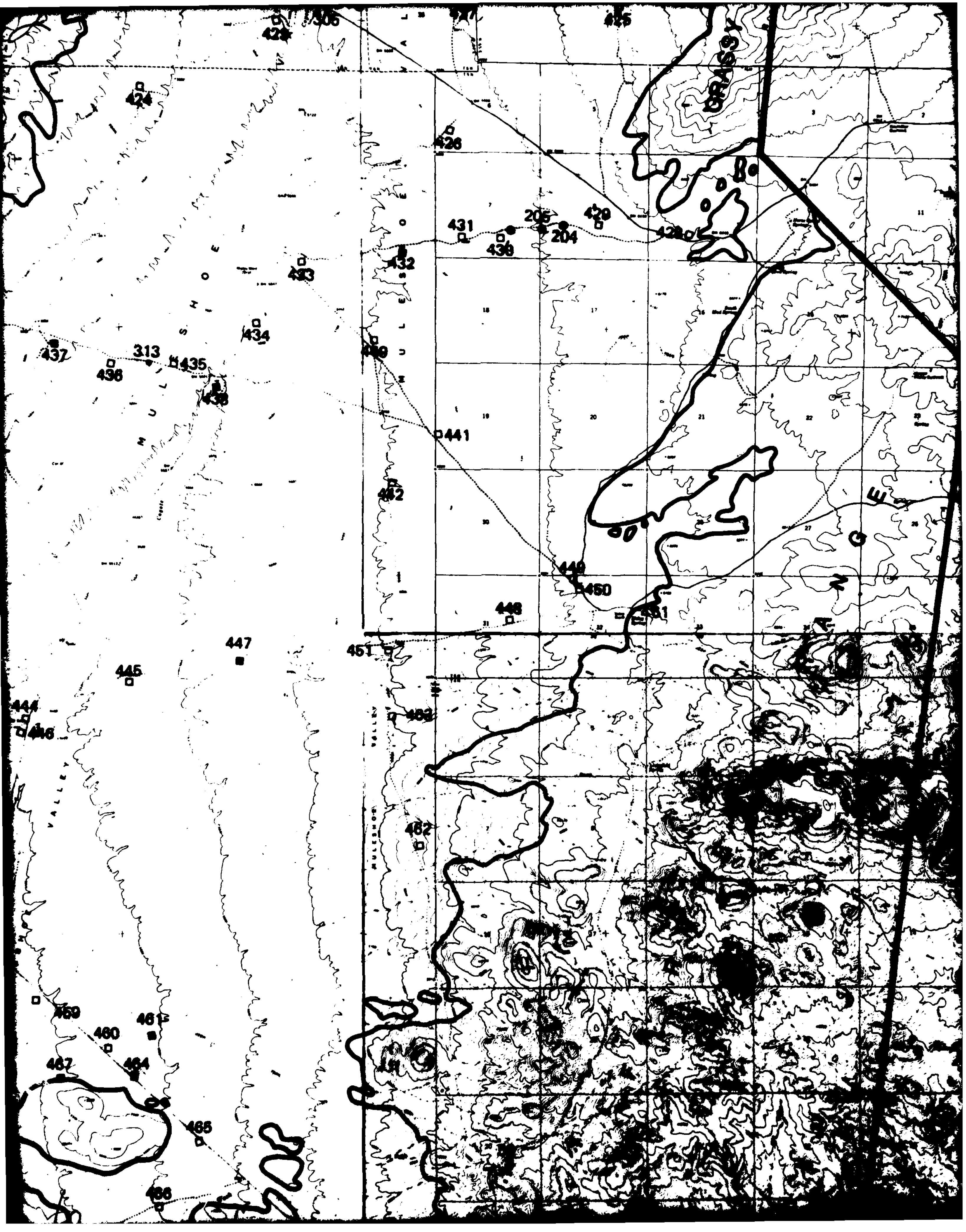

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EXPLA

ERTEC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- ○ DATA STOP

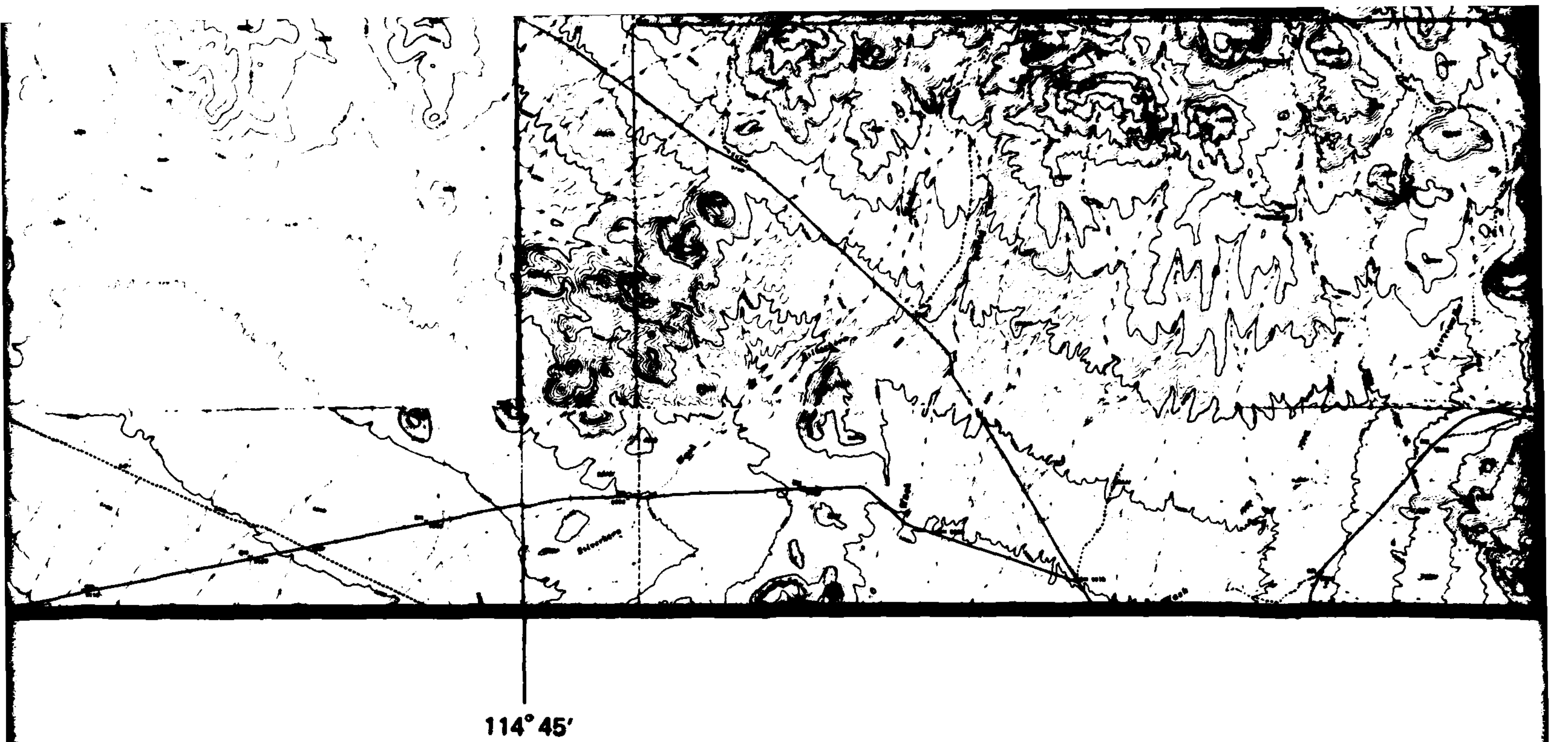
ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED
- △ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN -FILL UNITS (COARSE AND/OR FINE AGGREGATES)

a



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EXISTING ERTEC WESTERN TEST DATA LOCATIONS ***
(MAP NUMBERS FROM 400 TO 599)

- ■ DATA STOP, SAMPLED AND TESTED
- □ DATA STOP

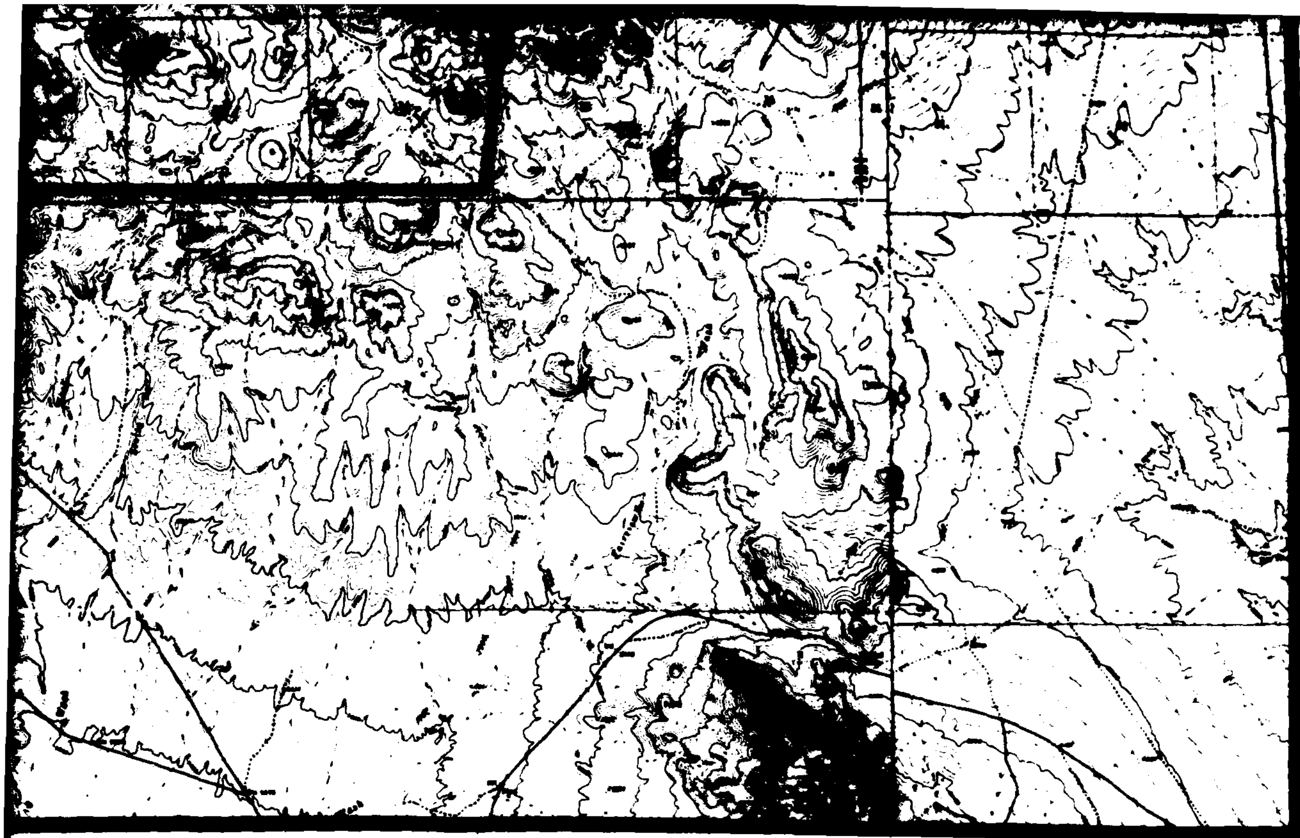
* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-a) FOR DETAILED INFORMATION.

** SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

*** SEE CORRESPONDING MAP NUMBER AND ACTIVITY TYPE IN APPENDIX G FOR REFERENCE TO THE IN PROGRESS MULESHOE VALLEY VERIFICATION REPORT (E-TR-27-MS-I AND II).

SYMBOLS

▬ STUDY AREA BOUNDARY



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SCALE 1:62,500

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STATUTE MILES

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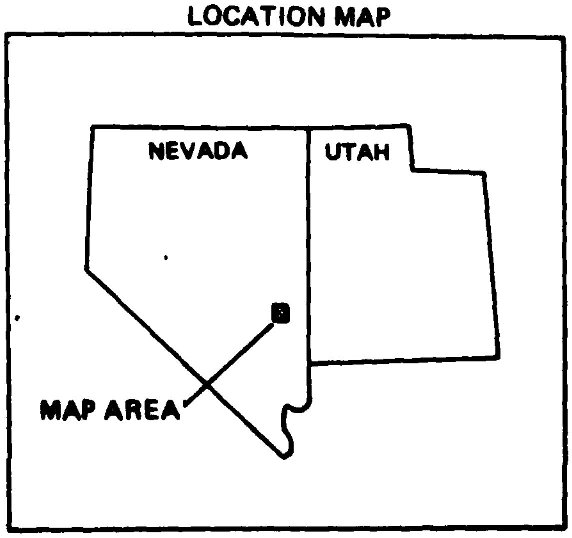
PENDICES A AND B

ACTIVITY TYPE IN
ROGRESS MULESHOE
MS-I AND II).

LOCATION MAP



EXPLANA

ERTEC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- ○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED
- △ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN -FILL UNITS (COARSE AND/OR FINE AGGREGATES)

9

- ● DATA STOP, SAMPLED AND TESTED
- ○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

- • DATA STOP

114° 45'

TION

EXISTING ERTEC WESTERN TEST DATA LOCATIONS ***
(MAP NUMBERS FROM 400 TO 599)

■ DATA STOP, SAMPLED AND TESTED

□ DATA STOP

* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-a) FOR DETAILED INFORMATION.

** SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

*** SEE CORRESPONDING MAP NUMBER AND ACTIVITY TYPE IN APPENDIX G FOR REFERENCE TO THE IN PROGRESS MULESHOE VALLEY VERIFICATION REPORT (E-TR-27-MS-I AND II).

SYMBOLS

STUDY AREA BOUNDARY

ROCK/BASIN—FILL CONTACT

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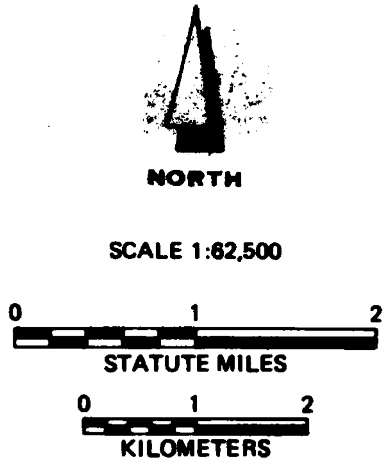
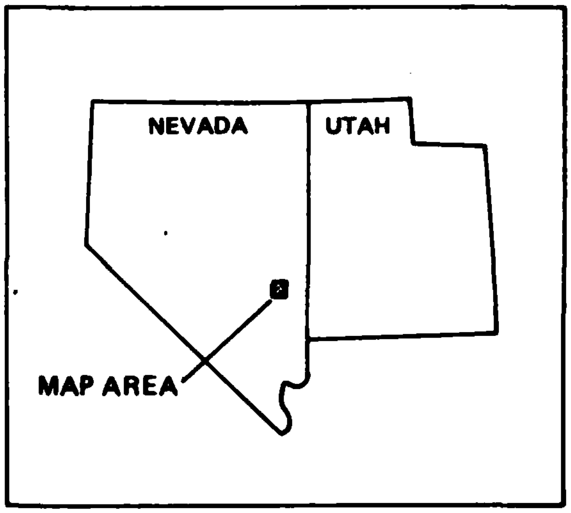


LOCATION MAP



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ES A AND B

Y TYPE IN
S MULESHOE
D II).

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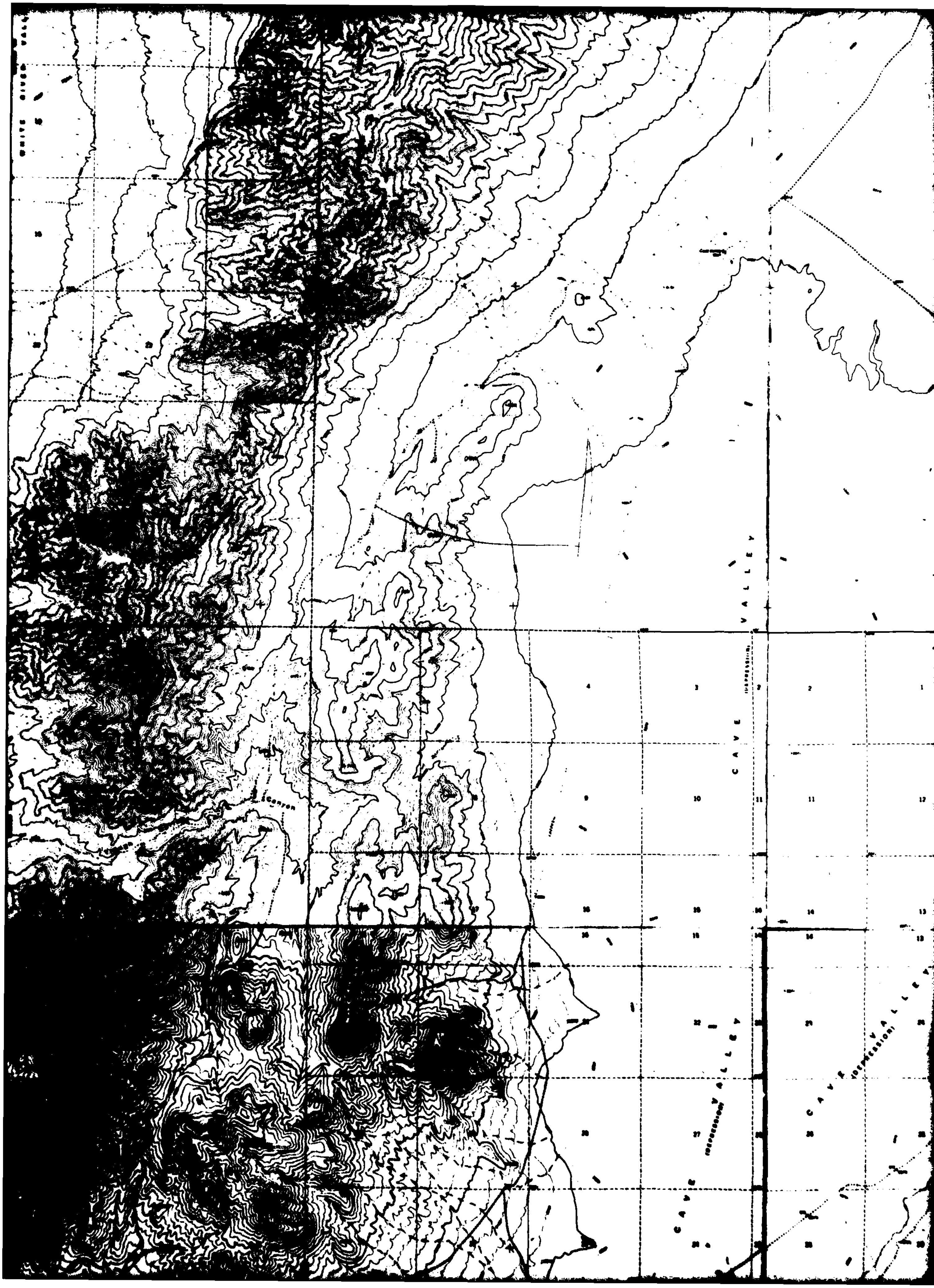
The Earth Technology Corporation

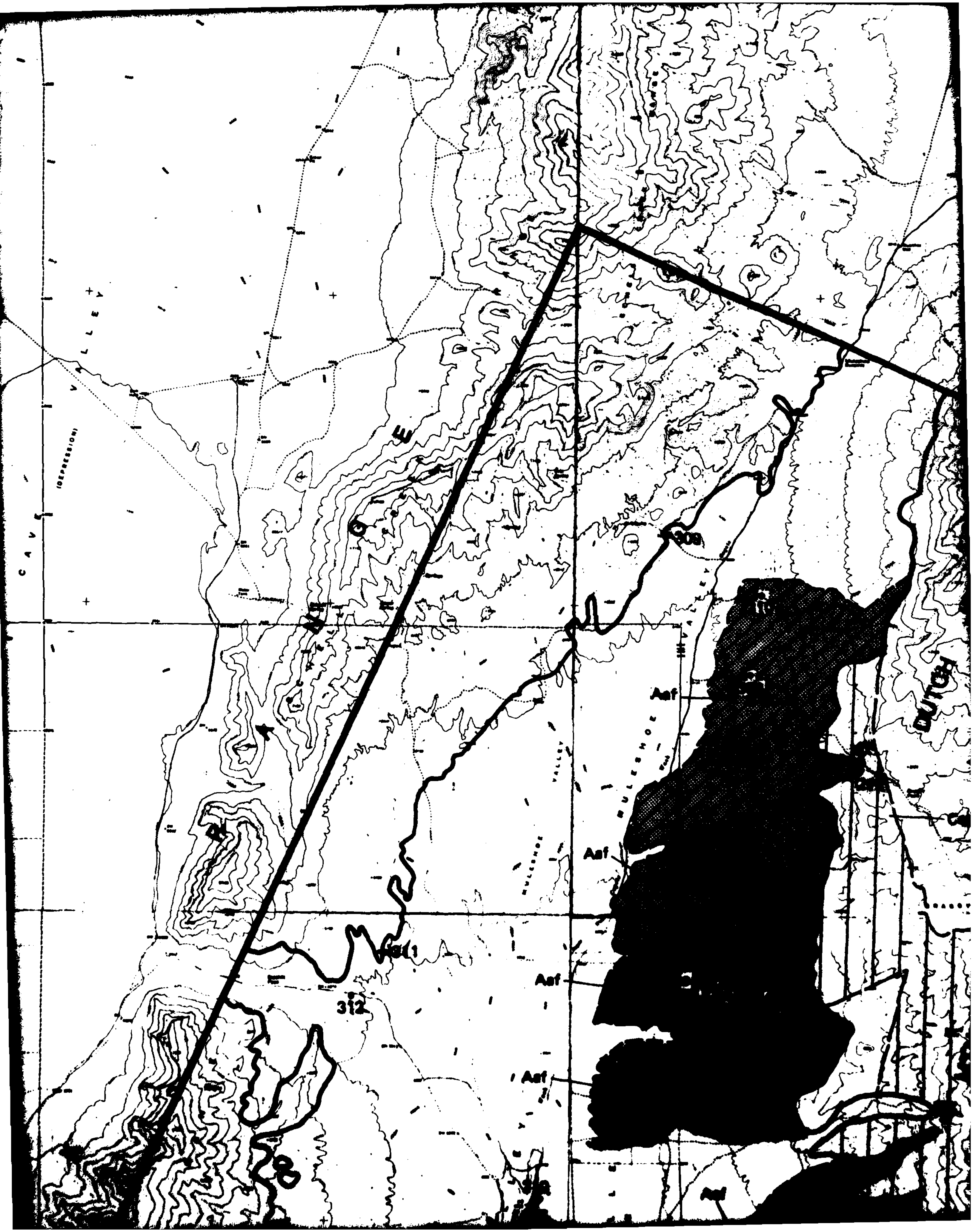
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

FIELD STATION AND SELECTED EXISTING DATA SITE LOCATIONS DETAILED AGGREGATE RESOURCES STUDY MULESHOE VALLEY NEVADA

5 JUN 81

DRAWING 1


CAVE VALLEY
CAVE VALLEY (DEPRESSION)


CAVE VALLEY
(DEPRESSION)
MULESHOE VALLEY
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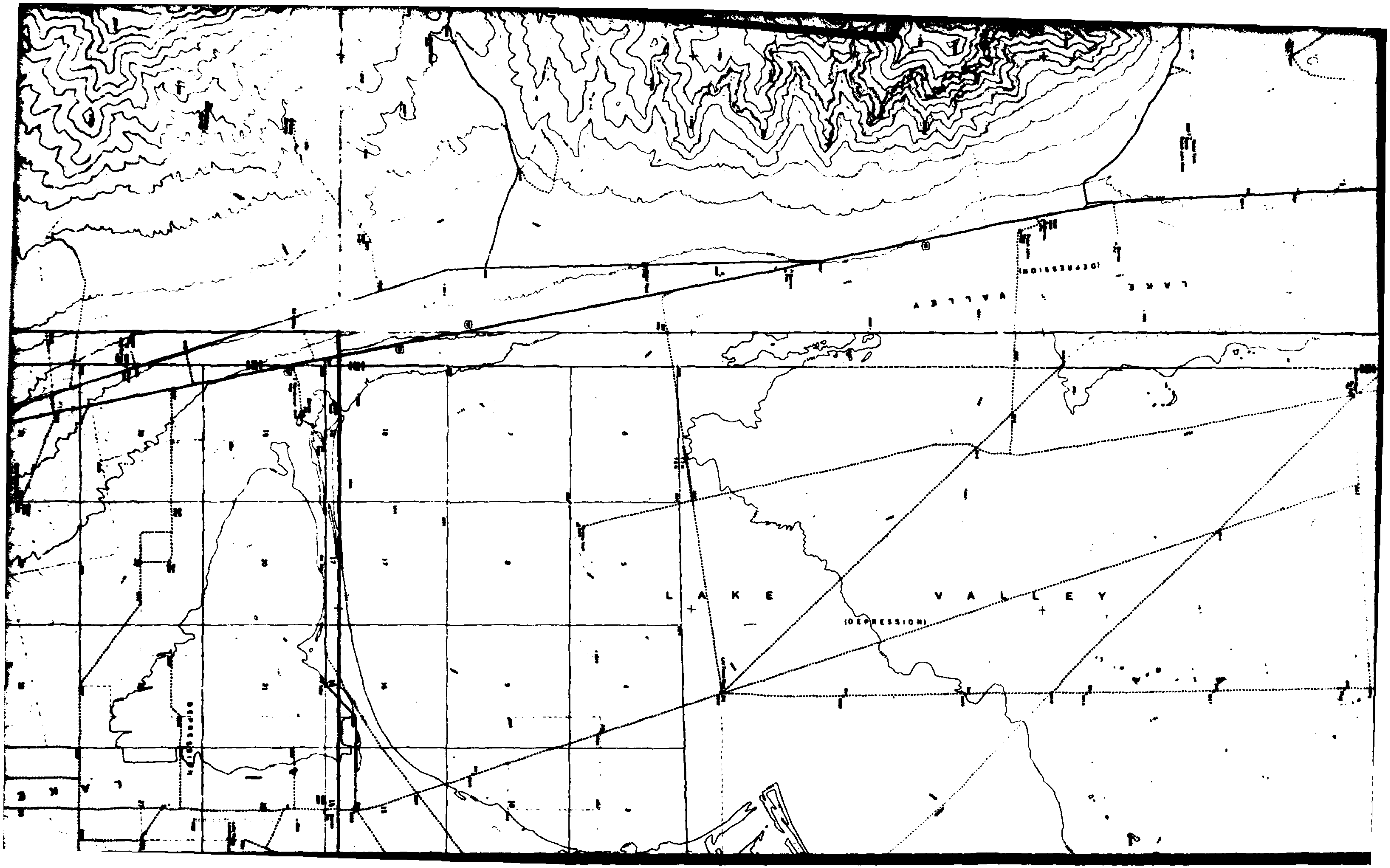
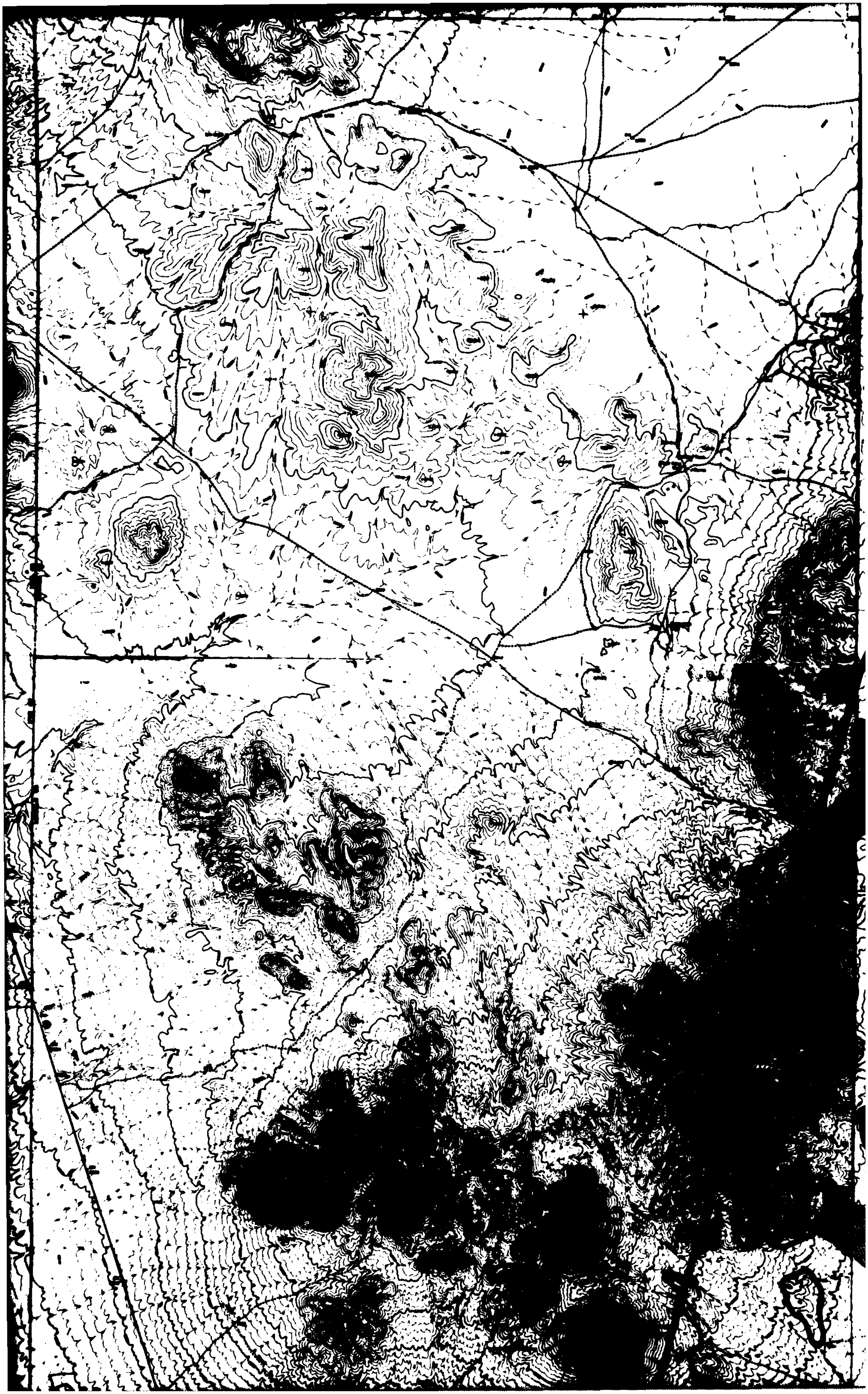
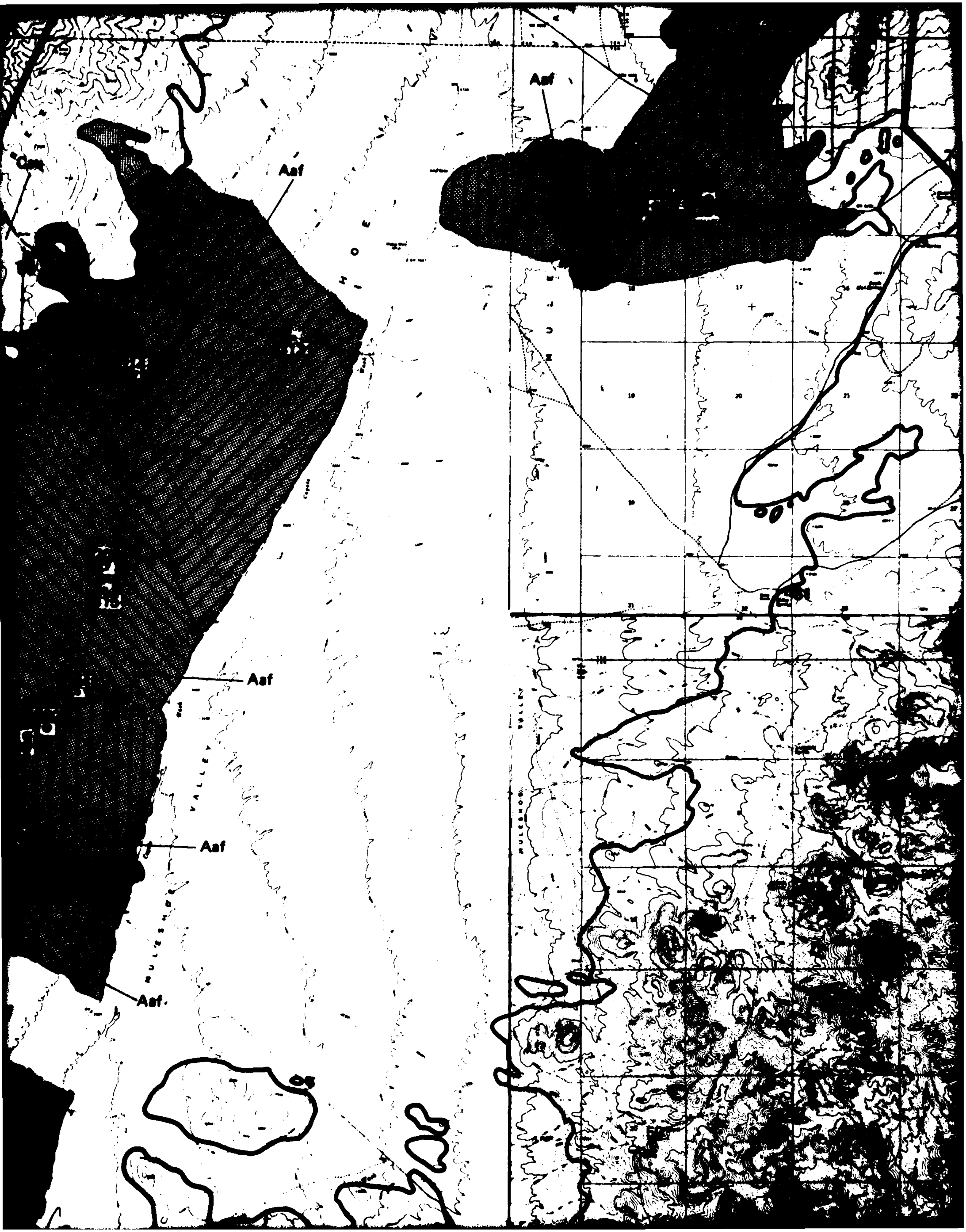
DUTCH


LAKE VALLEY
(DEPRESSION)

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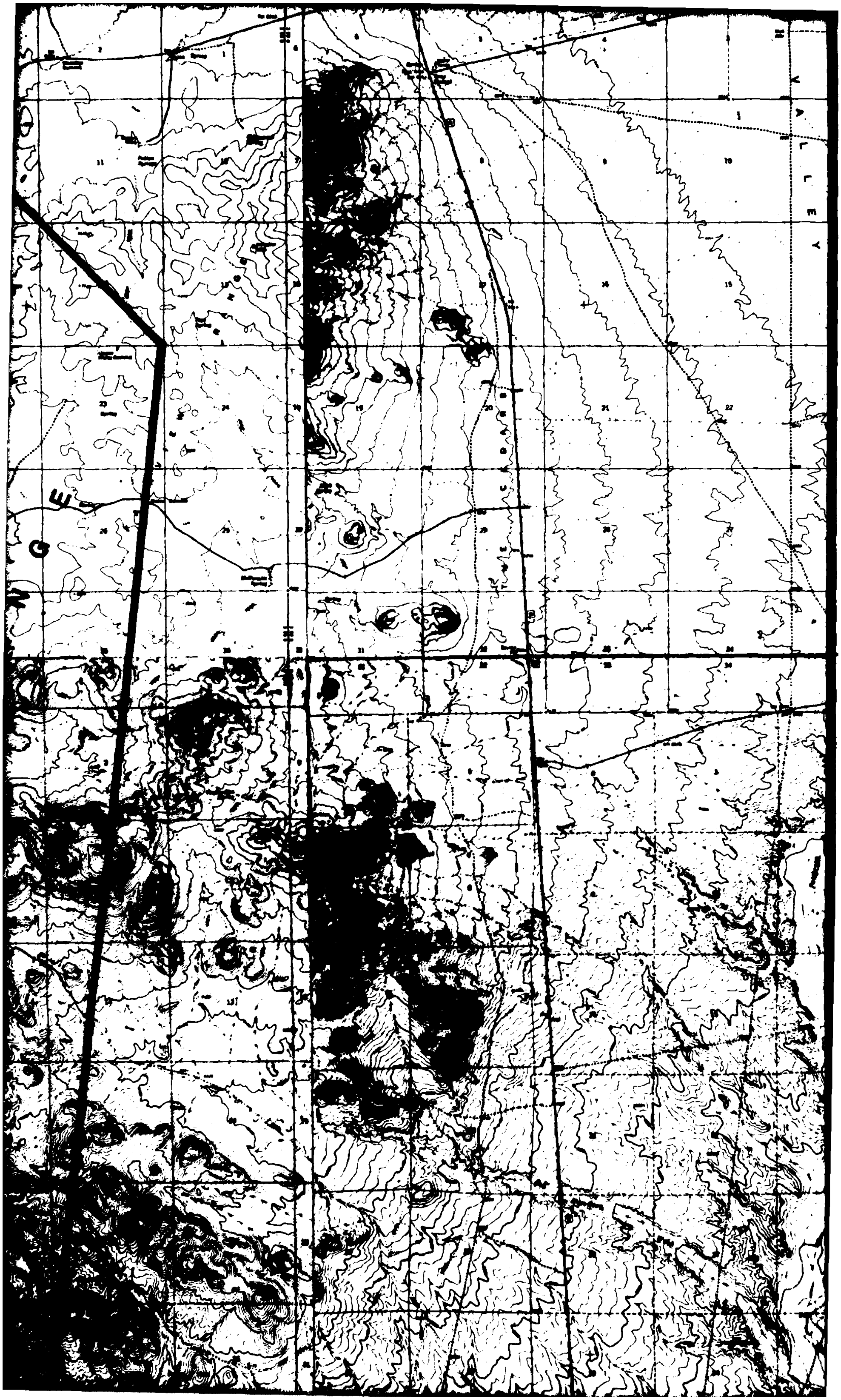
VALLEY

EC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY*
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- o DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED
- ▵ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY**
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- o DATA STOP

a

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BASIN–FILL AND ROCK S

RBIa BASIN FI
ROCK

RBIb BASIN FI

RBII BASIN FI

*** A COMPLETE CLAS
BASIN–FILL OR R
THE STUDY AREA.

114° 45′

EXPLANATION

REGATE CLASSIFICATION SYSTEM

URCES * * *

BASIN–FILL OR ROCK SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.

BASIN–FILL SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON CORRELATION WITH CLASS RBIa SOURCE AREAS.

POTENTIAL BASIN–FILL SOURCES OF MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON PHOTOGEOLOGIC INTERPRETATIONS, FIELD OBSERVATIONS, AND LIMITED OR INCONCLUSIVE SIEVE ANALYSIS AND/OR ABRASION DATA.

UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

CATION SYSTEM IS SHOWN, ALTHOUGH ALL
SOURCES MAY NOT BE PRESENT WITHIN

GEOLOGIC UNITS †

BASIN–FILL UNIT

Aaf ALLUVIAL FAN D

ROCK UNITS

Cau CARBONATE ROC

† SEE APPENDIX TABLE F-3 FOR SYM

SYMBOLS ††

STUDY AREA BO

ROCK/BASIN–FI

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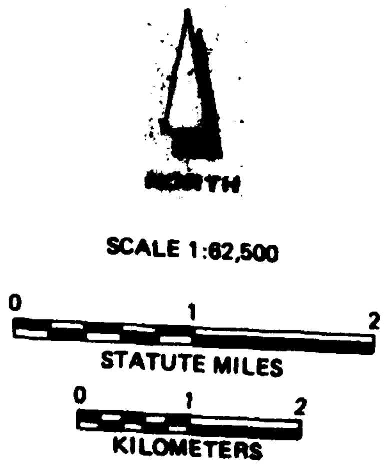

L UNITS

FAN DEPOSITS (A5)

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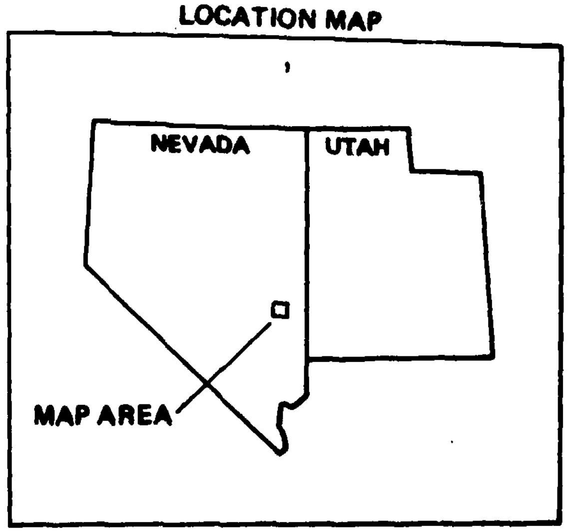
ATE ROCKS UNDIFFERENTIATED (S2)

R SYMBOL EXPLANATION AND COMPARISON

LOCATION MAP



REA BOUNDARY

SIN—FILL CONTACT

IC ROCK CONTACT

ILL CONTACT

ERTEC WESTERN AGGREGATE RE[illegible]

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY*
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- ○ DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED
- △ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY**
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- ○ DATA STOP

9

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

- • DATA STOP

* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-e) FOR DETAILED INFORMATION.

** SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

BASIN–FILL AND ROCK SOURCES * * *

RBIa		BASIN FILL	BASIN–FILL OR ROCK SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.
		ROCK	
RBIb		BASIN FILL	BASIN–FILL SOURCES CONTAINING MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON CORRELATION WITH CLASS RBIa SOURCE AREAS.
RBII		BASIN FILL	POTENTIAL BASIN–FILL SOURCES OF MATERIALS SUITABLE FOR USE AS ROAD-BASE AGGREGATES; BASED ON PHOTOGEOLOGIC INTERPRETATIONS, FIELD OBSERVATIONS, AND LIMITED OR INCONCLUSIVE SIEVE ANALYSIS AND/OR ABRASION DATA.
			UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

* * * A COMPLETE CLASSIFICATION SYSTEM IS SHOWN, ALTHOUGH ALL BASIN–FILL OR ROCK SOURCES MAY NOT BE PRESENT WITHIN THE STUDY AREA.

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† SEE APPE

SYMBOLS††

†† GEOLOG
APPROX

BASIN-FILL UNITS

Aaf	ALLUVIAL FAN DEPOSITS	([illegible])

ROCK UNITS

Cau	CARBONATE ROCKS UNDIFFERENTIATED	([illegible])

† SEE APPENDIX TABLE F-3 FOR SYMBOL EXPLANATION AND COMPARISON

SYMBOLS ††

STUDY AREA BOUNDARY

ROCK/BASIN-FILL CONTACT

GEOLOGIC ROCK CONTACT

BASIN-FILL CONTACT

†† GEOLOGIC ROCK AND BASIN-FILL CONTACTS ARE APPROXIMATELY LOCATED AND MAY VARY LOCALLY.

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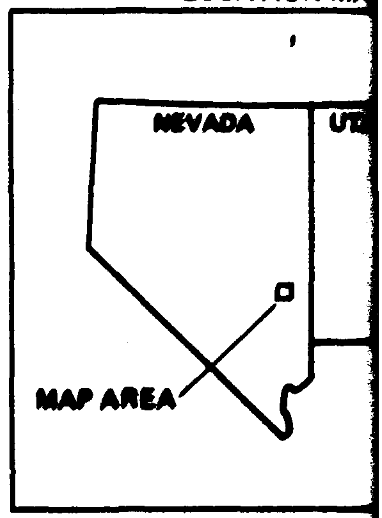

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The Earth Technology Corporation

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ROAD-BASE AGGREGA
DETAILED AGGREGAT
MULESHOE VA

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XPLANATION AND COMPARISON

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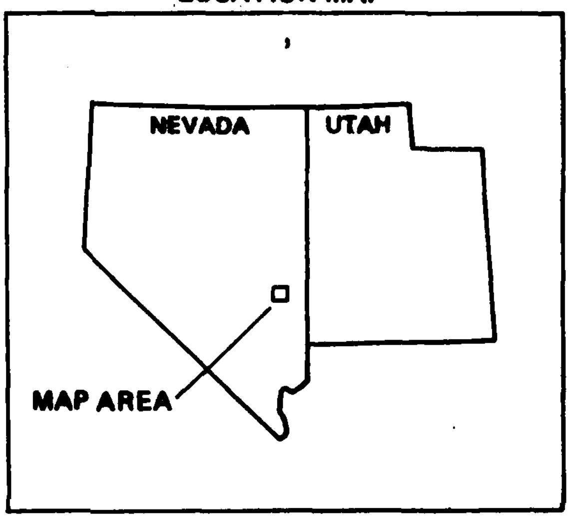
LOCATION MAP



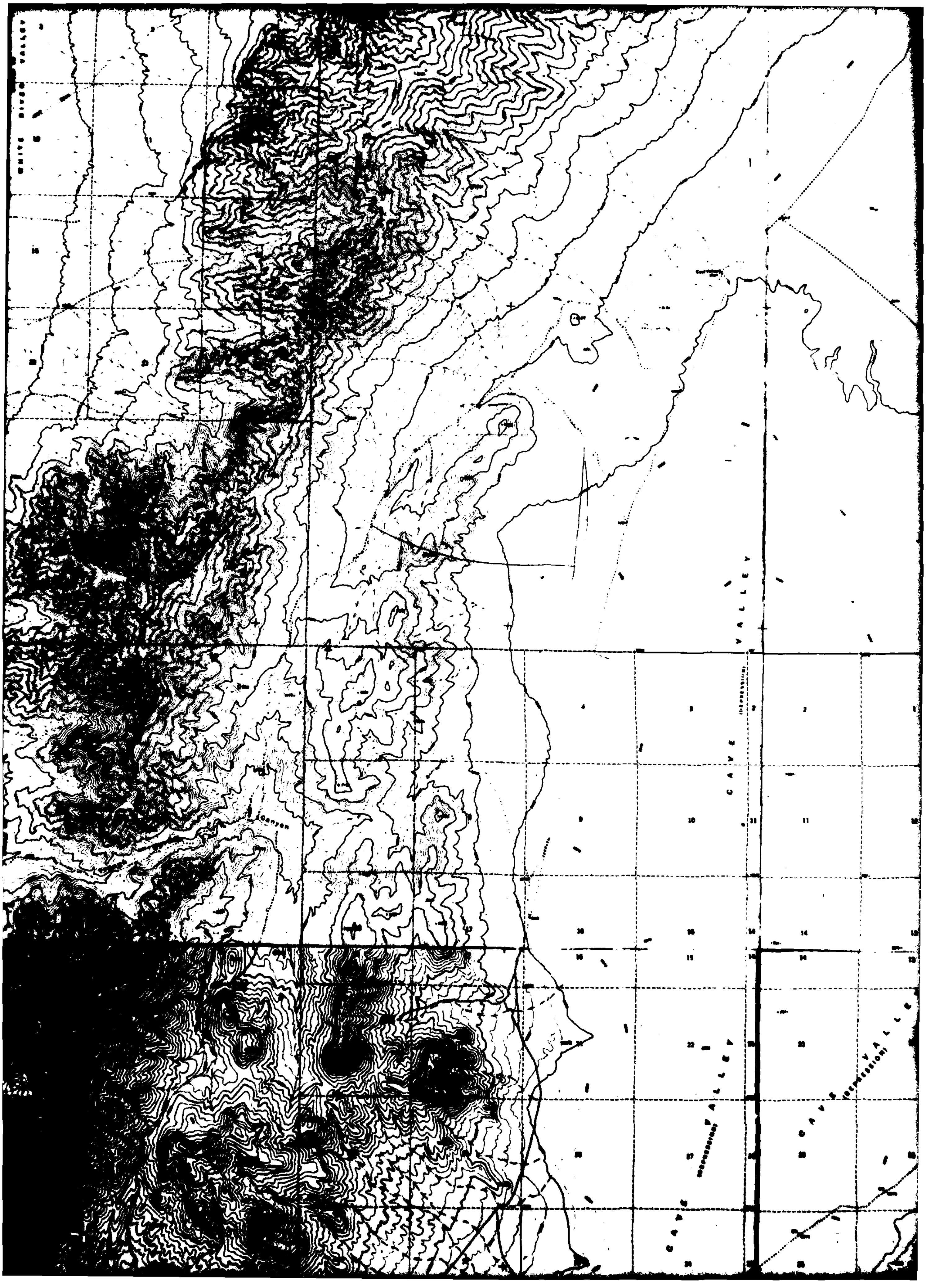
Ertec
The Earth Technology Corporation

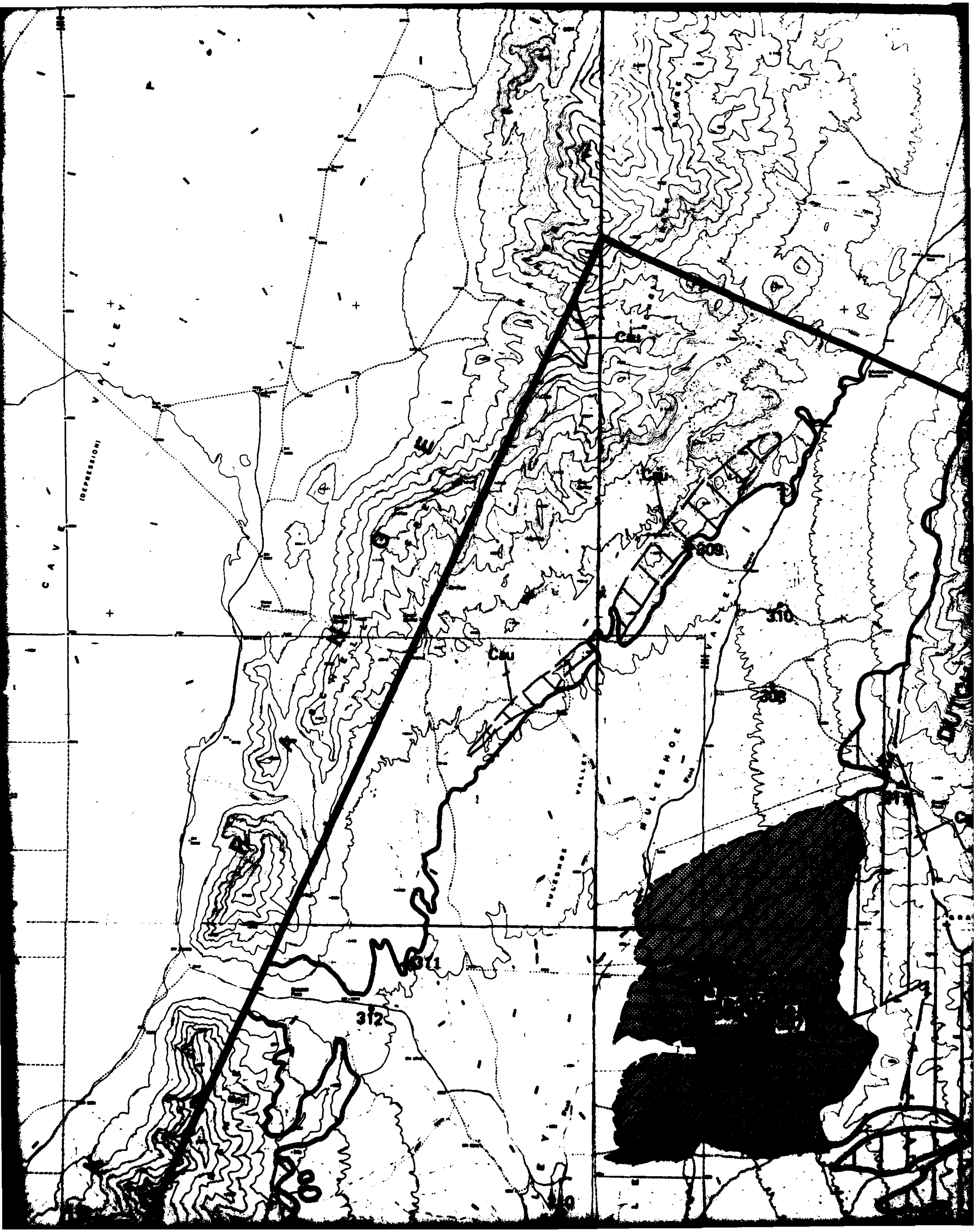
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE
BMO/AFRCE-MX

ROAD-BASE AGGREGATE RESOURCES MAP
DETAILED AGGREGATE RESOURCES STUDY
MULESHOE VALLEY, NEVADA

5 JUN 81

DRAWING 2


WHITE RIVER VALLEY
CAVE VALLEY
CAVE VALLEY
Canyon



CAVE VALLEY
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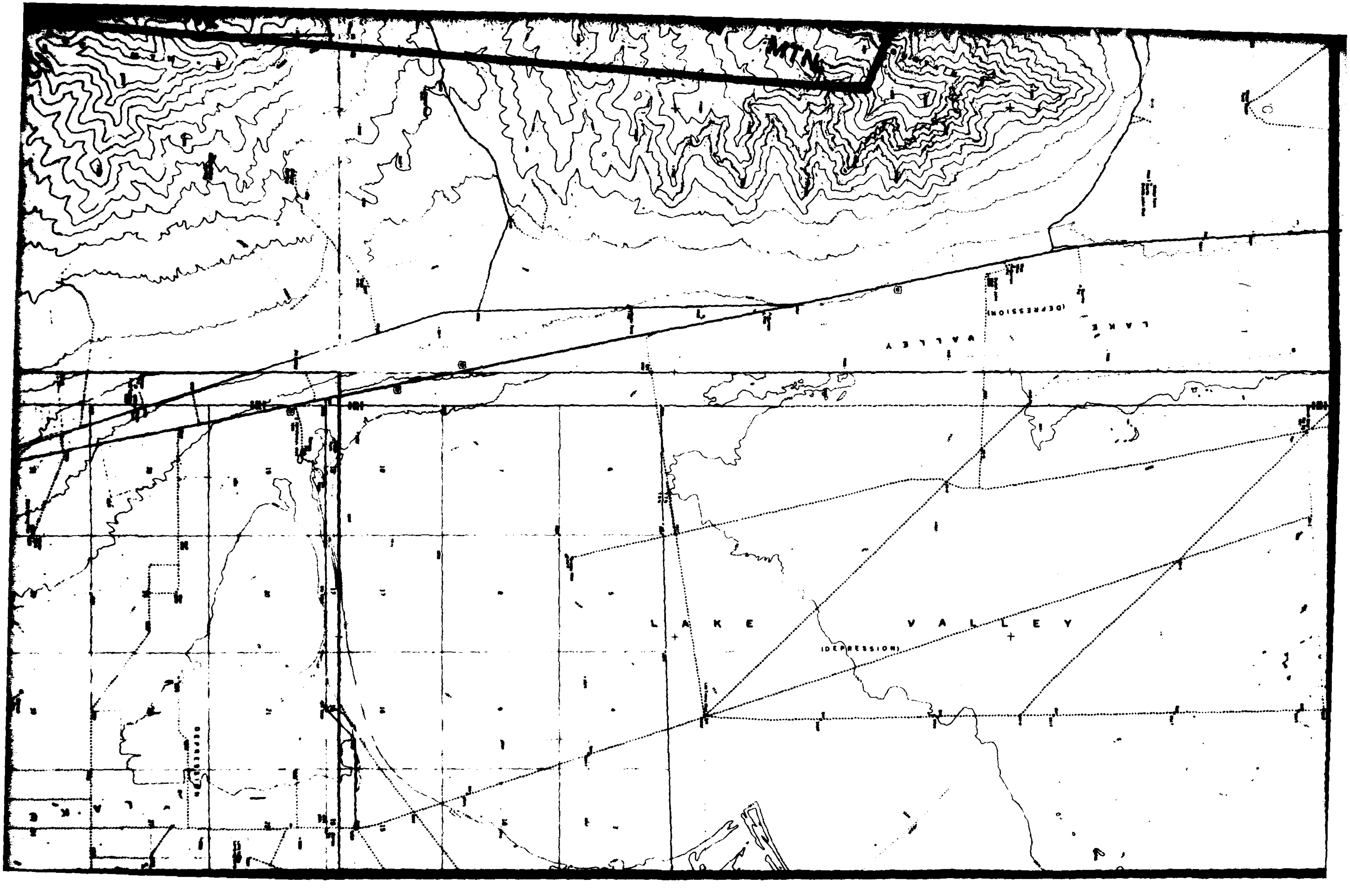
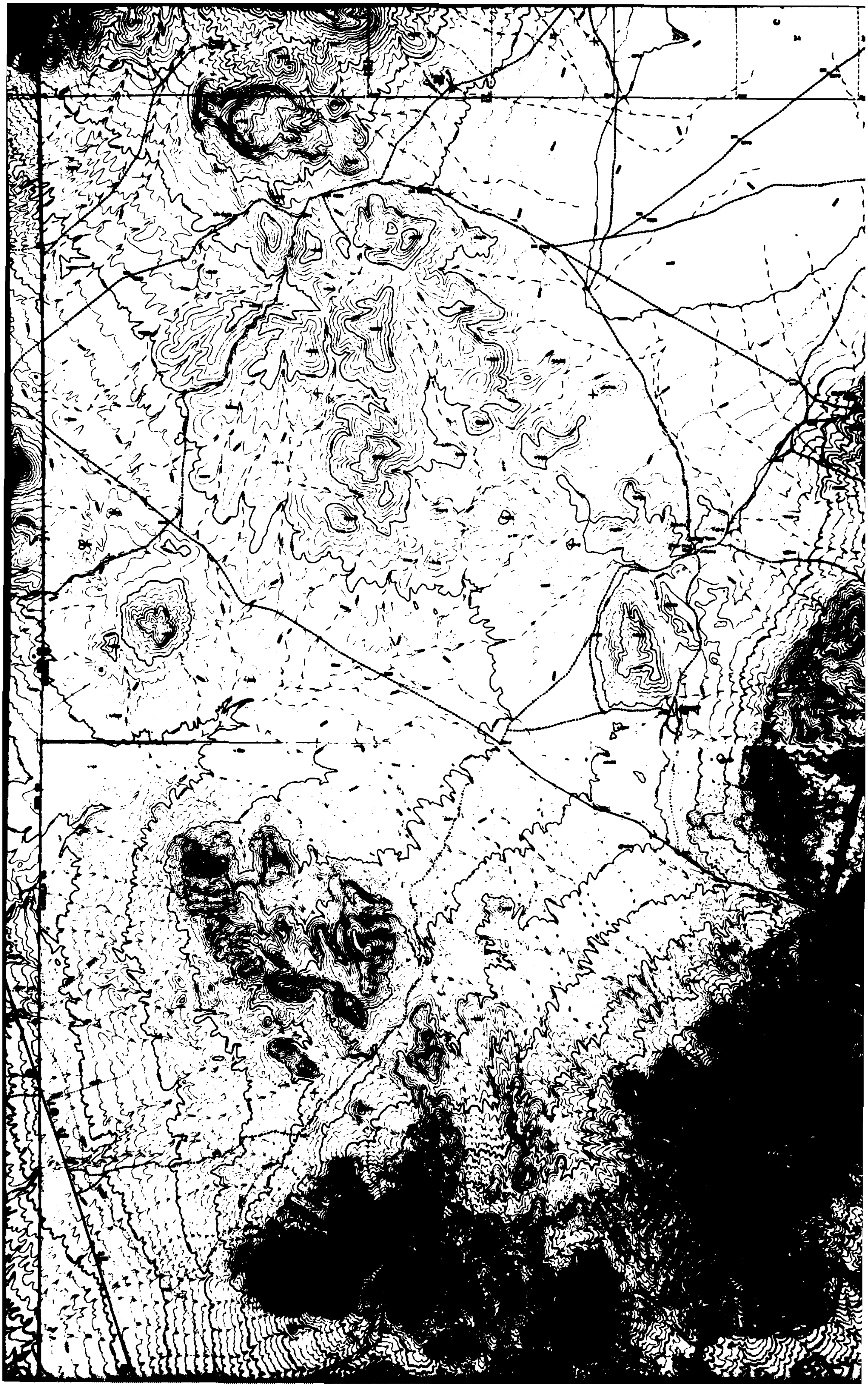
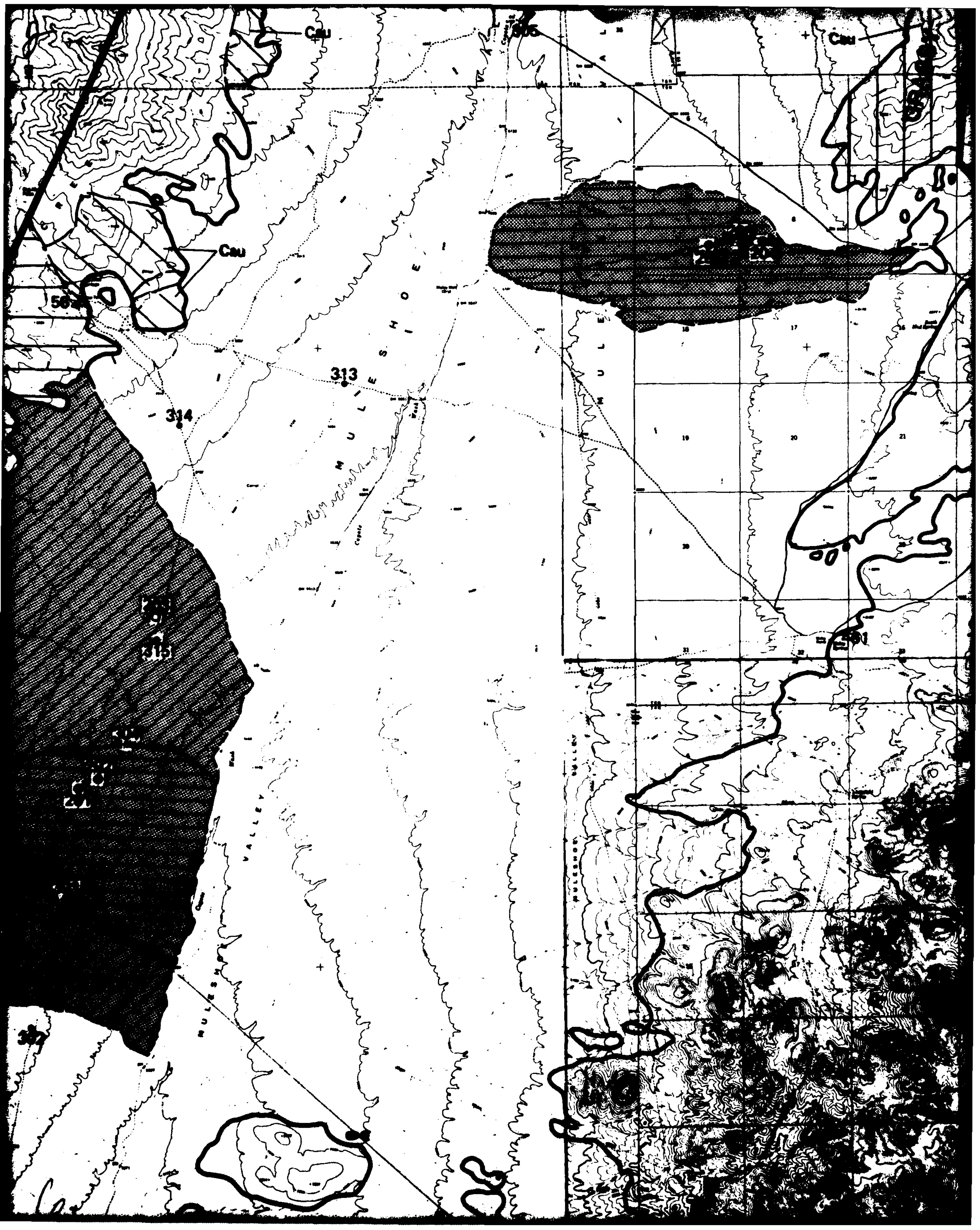
BULESHOE VALLEY



LAKE VALLEY
(DEPRESSION)
MTN





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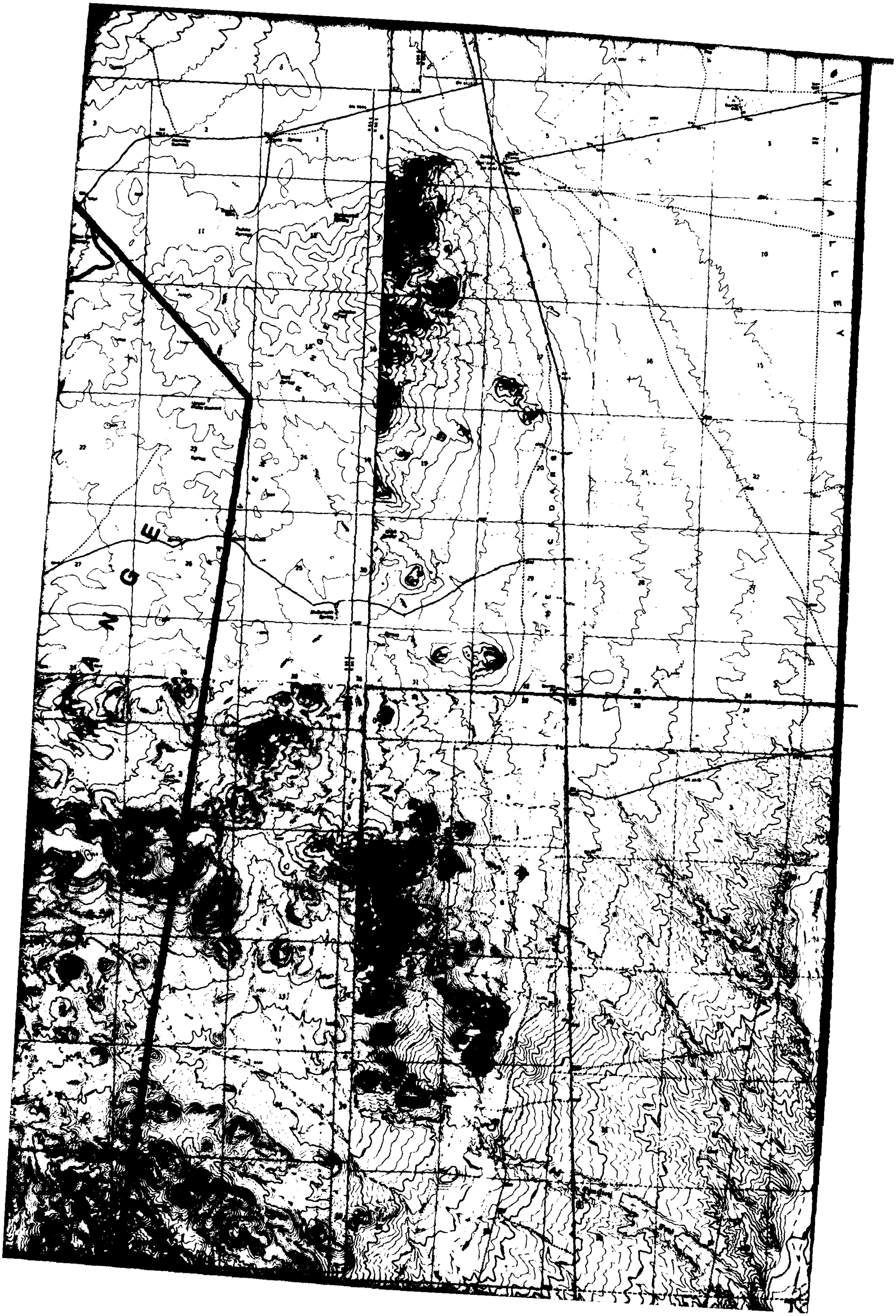
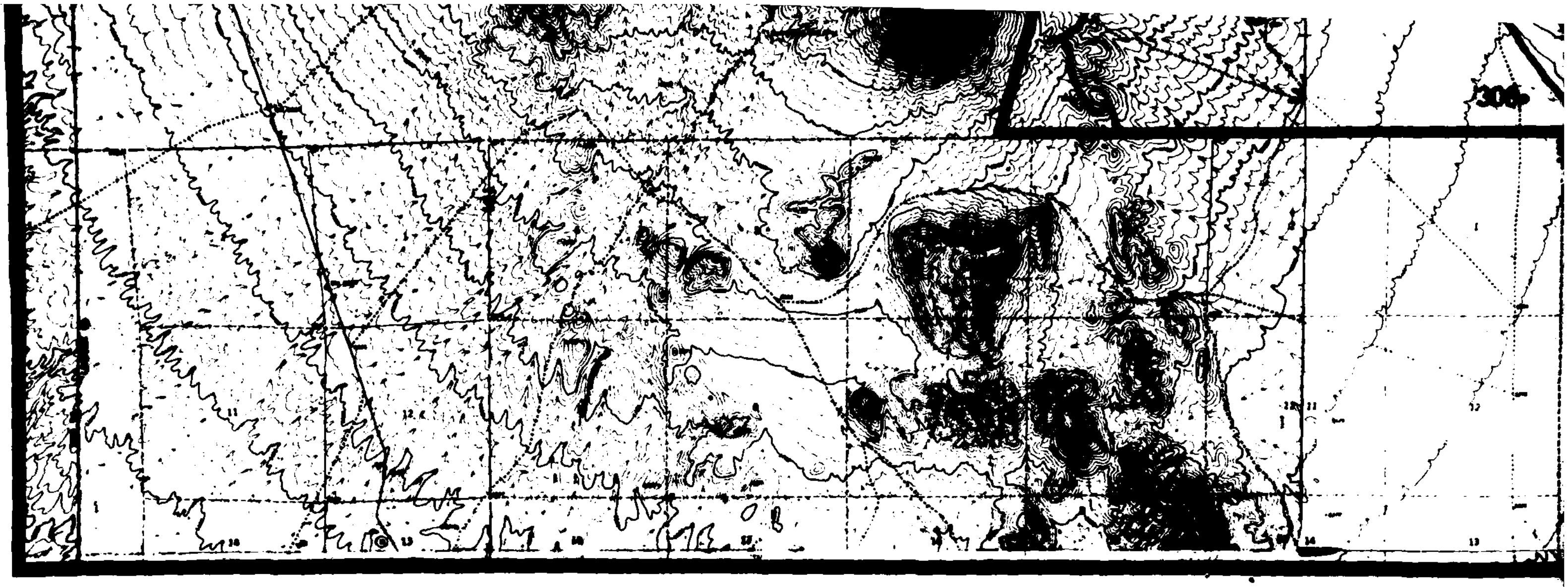

VALLEY



ERTEC WESTERN AGGREGATE RESOURCES STUDY FIELD STATIONS

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

o DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

▲ DATA STOP, SAMPLED AND TESTED

▲ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL
AND ROCK SAMPLE LOCATIONS, 300 TO 399
FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

● DATA STOP, SAMPLED AND TESTED

AGGREGATE CLASSIFICAT

BASIN–FILL AND ROCK S

CA1 BASIN FIL
ROCK

CA2 BASIN FIL
ROCK

CB BASIN FI
ROCK

CC1 BASIN F
ROCK

CC2 BASIN F

114° 45′

EXPLANATION

ION SYSTEM ***

URCES

L — BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS EQUAL TO OR GREATER THAN 6500 PSI.

L — BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS LESS THAN 6500 PSI.

L — BASIN -FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.

LL — BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CA1 OR CA2 SOURCE AREAS.

L — BASIN–FILL SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CB SOURCE AREAS.

GEOLOGIC UNITS †

BASIN–FILL U

Aaf — ALLUVIAL FA

ROCK UNITS

Cau — CARBONATE

† SEE APPENDIX TABLE F-3 FOR SY

SYMBOLS ††

STUDY ARE

ROCK/BASI

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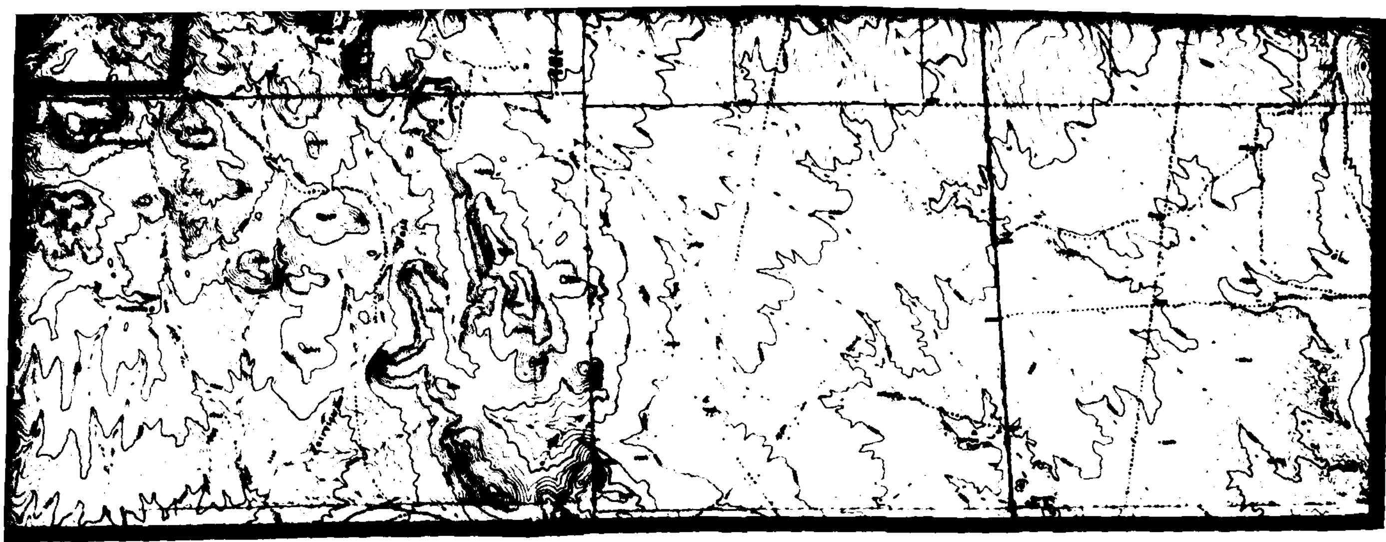
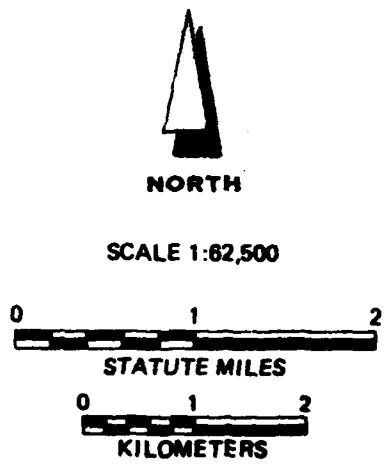




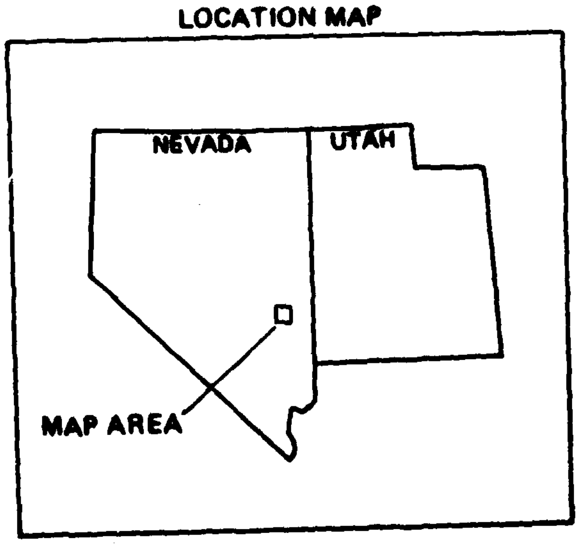
NITS

N DEPOSITS (A5)

ROCKS UNDIFFERENTIATED (S2)

MBOL EXPLANATION AND COMPARISON

LOCATION MAP



A BOUNDARY

-FILL CONTACT

OCK CONTACT

11

VALLEY–SPECIFIC AGGREGATE RESOURCES STUDY *
(MAP NUMBERS FROM 1 TO 199)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- o DATA STOP

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED
- ▲ DATA STOP

DETAILED AGGREGATE RESOURCES STUDY * *
(MAP NUMBERS FROM 200 TO 299 FOR BASIN–FILL AND ROCK SAMPLE LOCATIONS; 300 TO 399 FOR FIELD PETROGRAPHIC STATIONS)

BASIN–FILL UNITS (COARSE AND/OR FINE AGGREGATES)

- ● DATA STOP, SAMPLED AND TESTED
- o DATA STOP

9

ROCK UNITS (CRUSHED-ROCK AGGREGATES)

- ▲ DATA STOP, SAMPLED AND TESTED

PETROGRAPHIC FIELD STATIONS

- • DATA STOP

* SEE DRY LAKE, MULESHOE, DELAMAR, PAHROC VSARS REPORT (FN-TR-37-a) FOR DETAILED INFORMATION.

* * SEE CORRESPONDING MAP NUMBER IN APPENDICES A AND B FOR DETAILED INFORMATION.

SOURCES

ILL BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS EQUAL TO OR GREATER THAN 6500 PSI.

ILL BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES THAT PRODUCED TRIAL MIX CONCRETE WITH 28-DAY COMPRESSIVE STRENGTHS LESS THAN 6500 PSI.

ILL BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON ACCEPTABLE LABORATORY AGGREGATE TEST RESULTS.

ILL BASIN–FILL OR ROCK SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CA1 OR CA2 SOURCE AREAS.

ILL BASIN–FILL SOURCES CONTAINING AGGREGATES POTENTIALLY SUITABLE FOR USE IN CONCRETE; BASED ON CORRELATION WITH CLASS CB SOURCE AREAS.

10

BASIN–FILL SOURCES CONTAINING FINE AGGREGATES USED WITH CRUSHED-ROCK SAMPLES FOR CERTAIN CONCRETE TRIAL MIXES.

UNSUITABLE SOURCES OF BASIN–FILL MATERIALS THAT MAY LOCALLY CONTAIN POTENTIALLY SUITABLE SOURCES OF AGGREGATES OF LIMITED EXTENT. UNTESTED SOURCES OF ROCK MATERIALS THAT MAY CONTAIN POTENTIALLY SUITABLE CRUSHED-ROCK AGGREGATES (SEE TEXT FOR ADDITIONAL INFORMATION).

SIFICATION SYSTEM IS SHOWN, ALTHOUGH ALL
OCK SOURCES MAY NOT BE PRESENT WITHIN

BASIN–FILL

Aaf ALLUVIAL

ROCK UNIT

Cau CARBONAT

† SEE APPENDIX TABLE F-3 FOR S

SYMBOLS ††

STUDY AR

ROCK/BASI

GEOLOGIC

BASIN–FI

†† GEOLOGIC ROCK AND BASIN-
ARE APPROXIMATELY LOCAT
VARY LOCALLY.

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SCALE 1:62,500

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STATUTE MILES

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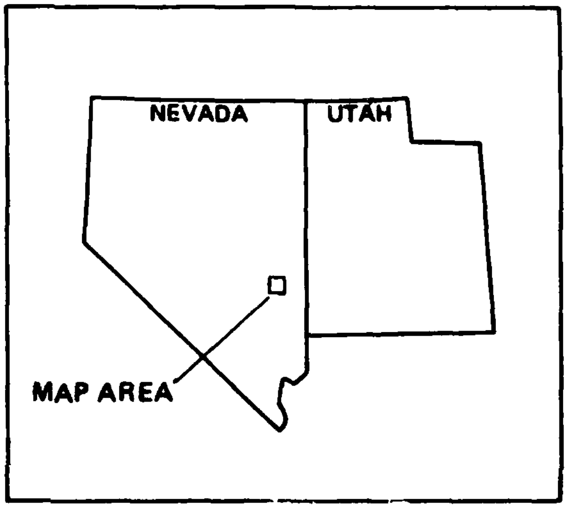
KILOMETERS

TS (A5)

NDIFFERENTIATED (S2)

LANATION AND COMPARISON

LOCATION MAP



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BMO/AFRCE-MX

CONCRETE AGGREGATE RESOURCES MAP
DETAILED AGGREGATE RESOURCES STUDY
MULESHOE VALLEY, NEVADA

5 JUN 81

DRAWING 3

DATE
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